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Cover.—An enlarged section of the photograph of a stack of Florida lobster traps on page 28. See the article by Bruno J. Noetzel and Mikolaj G. Wojnowski beginning on page 25.

Fishing Fleet Activities Revealed by Night-Time Data from the Defense Meteorological Satellite Program (DMSP)

ROBERT W. FETT

The effect of ocean thermal boundaries on the distribution of fish is well known in the fishing industry. Laevastu and Hela (1970) additionally describe the role of oceanic current convergences in bringing about a concentration of forage organisms and small fish highly attractive to pelagic tuna. They show a weekly, combined surface temperature and oceanic chart published by Japanese newspapers for the benefit of the fisheries, which locates the meander of the various zones in their area.

Figure 1 shows the major physical oceanographic features surrounding Japan and Korea (Gong, 1971). A notable convergence zone is the zone of mixing between the cold Liman Current and the warm Tsushima Current in the Sea of Japan. Figure 2 is a Very High Resolution ($\frac{1}{2}$ km) infrared depiction of the convergence zone obtained from the sensors of the Defense Meteorological Satellite Program (DMSP) on the night of 26 September 1974. In this depiction the warm areas are black; progressively cooler areas are lighter shades of grey, culminating in white for very high and very cold cirrus cloudiness. The warmer waters in the southern portion of the Sea of Japan are readily distinguishable from the colder waters to the north. According to the previous reasoning, the convergence zone, or zone of mixing separating these two areas, should be a very good place to fish for tuna, saury, and other pelagic

varieties of fish. Figure 3 suggests that the fishermen in that area were not caught off their guard and were very active in exploiting the fishing potential of this convergence zone. The depiction is from the visual scanner (3-km resolution) of the DMSP, which is capable of acquiring night-time data with illumina-

tion as low as $\frac{1}{4}$ moonlight. This depiction was acquired simultaneously with that of the infrared depiction shown in Figure 2. The city lights of Seoul, Korea on the west coast and Pusan on the southeast tip of Korea, along with others, are readily apparent. City lights in Japan, shining through overcast

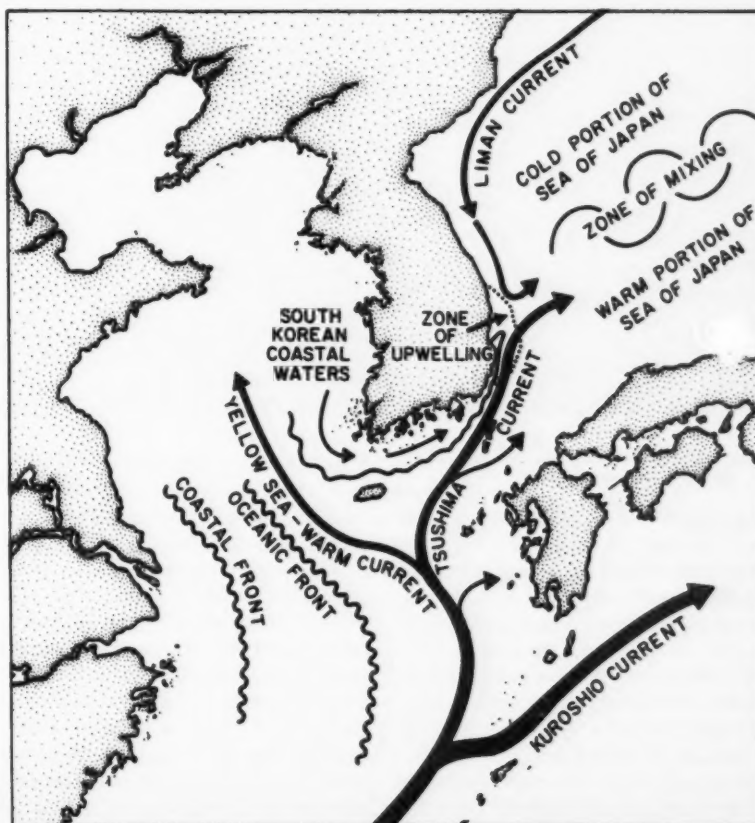


Figure 1.—Physical Oceanographic Features: (Photograph, courtesy of Gong, Kang, Cho, 1972 and U.S. NAVOCEANO.)

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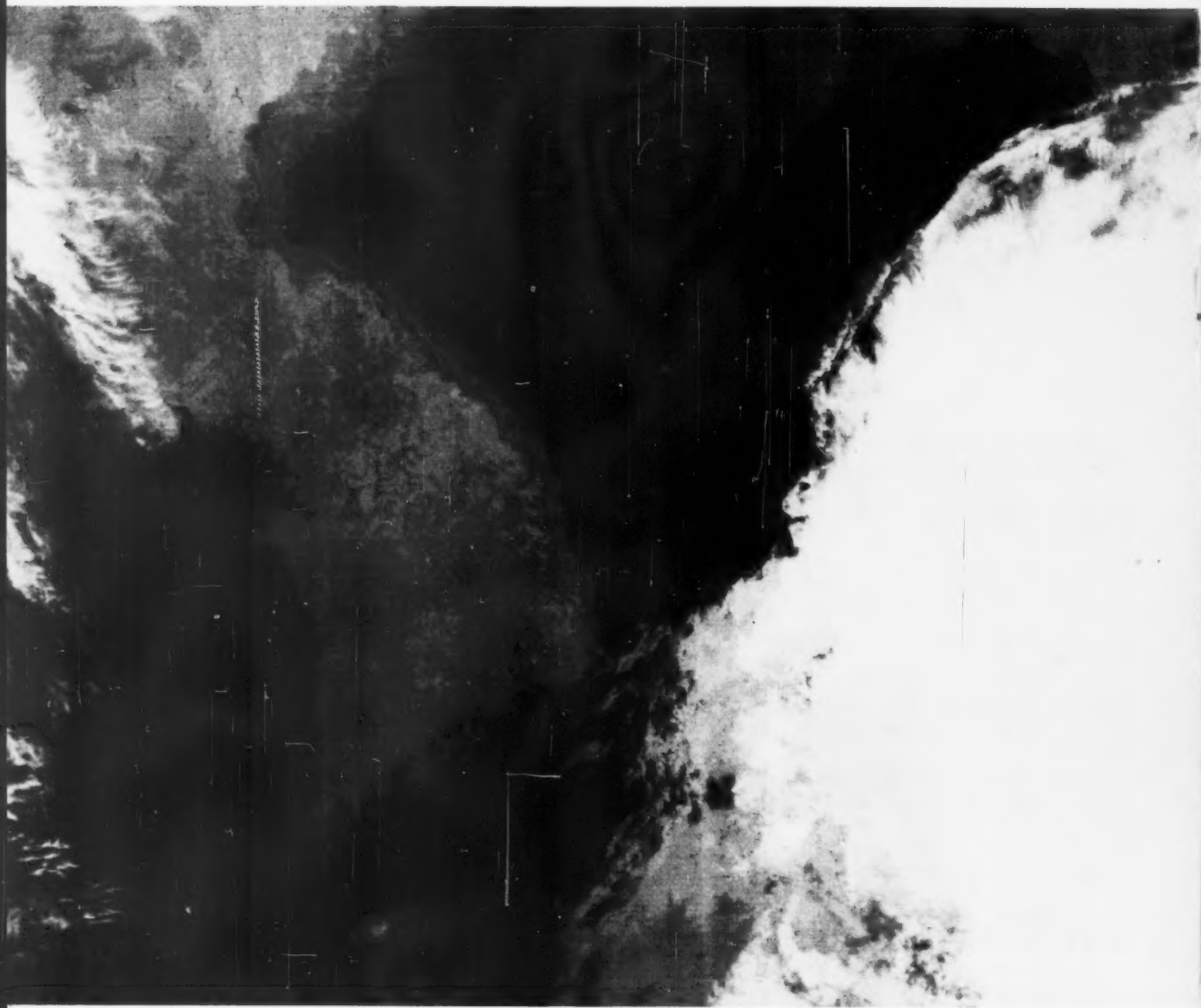


Figure 2.—A DMSP Very High Resolution Infrared depiction on 26 September 1974, at 1555 GMT.

cloudiness, are apparent to the southeast and east. But there are no cities under the lights covering the Sea of Japan! Revealed are lights from what appears to be a heavy concentration of vessels cruising along the convergence zone, or zone of mixing in the Sea of Japan, attempting to exploit the potential of this area for productive fishing. The intensity of the lighting is unusually strong, suggesting that the vessels are using exterior alluring lights in quest for Pacific saury, a species which prefers to congregate in waters near sharp thermal gradients. It has been found that at

night, at the surface, saury will form dense schools under rather intense artificial lights; 5 kw searchlights are commonly used in the search process to scan the surface waters for saury schools (Inoue and Hughes, 1971). The alluring lights, according to this reference, include incandescent lamps mounted on reflectors, in addition to colored fluorescent lighting with a combined power output of 30 kw or more. Such lighting can be quite brilliant, as shown by the photograph in Figure 4 of a fishing vessel searching for saury with alluring lights on. Lower intensity lighting is sometimes concurrently used when fishing for squid. As can be seen

from the picture, reflection of the lights off the surface of the water and into the spacecraft sensor may have been a factor accounting for the heightened intensity of illumination observed.

Such a possibility seems especially important in this instance since a pronounced ridge of high pressure extended over the Sea of Japan and maximum winds in the area were only $1\frac{1}{2}$ m/sec⁻¹ (2-3 knots). The satellite tracked almost directly over the Sea of Japan so that atmospheric attenuation was minimized and specular reflection could be received from ship lights off the smooth surface of a gently rolling sea.

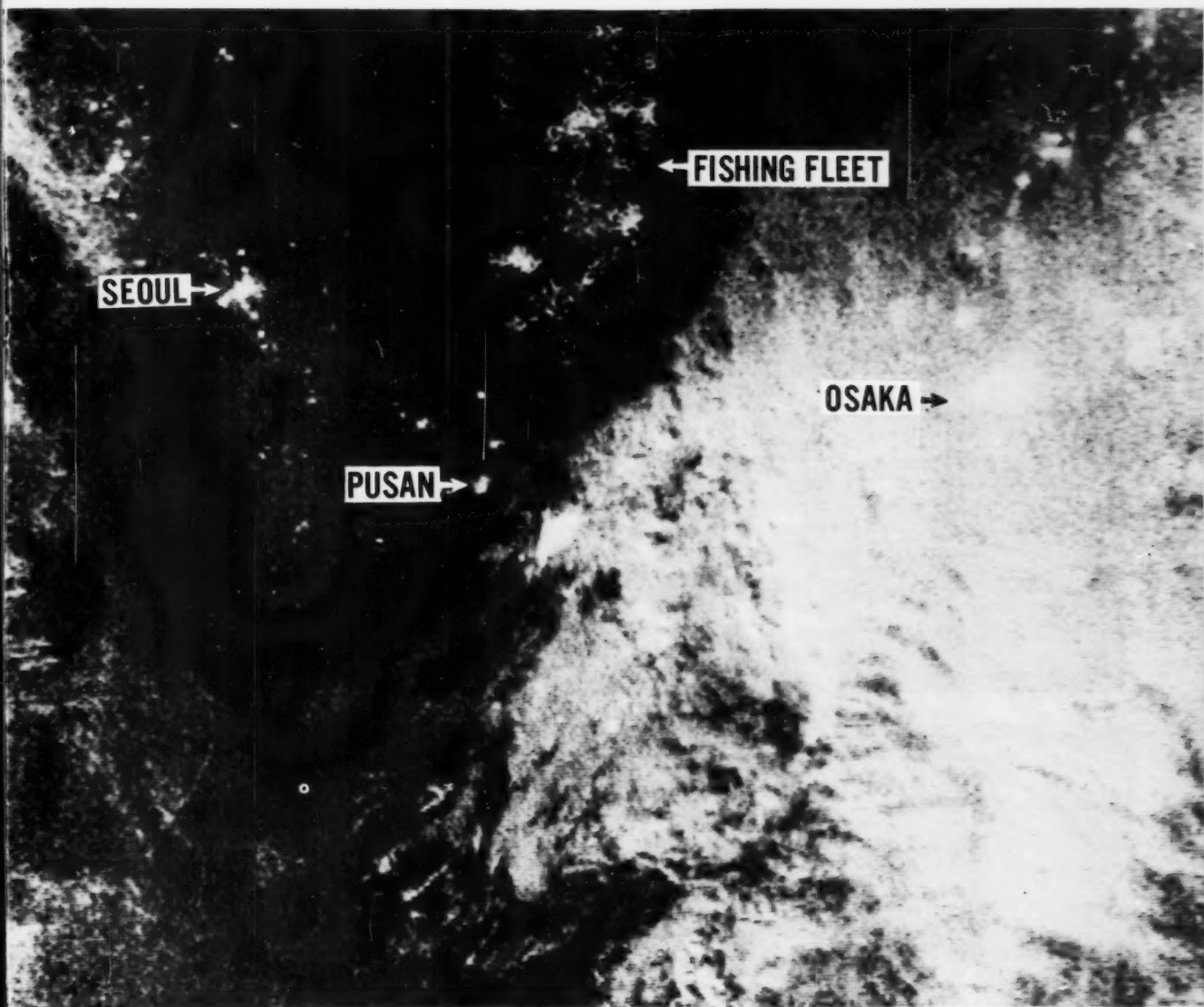


Figure 3.—A DMSP visual depiction of night-time data acquired on 28 September 1974, at 1555 GMT.

To account for the number of scan spots illuminated would require a minimum of 500-1,000 fishing vessels in the area. Private conversation with S. Hughes (Northwest Fisheries Center, NMFS, Seattle, WA 98102), co-author of the referenced saury study (Inoue and Hughes, 1971), indicates that such a figure or higher is not unrealistic, based on knowledge of Inoue's personal experiences with the saury fleet.

A possible alternative to the fishing fleet hypothesis is that the area was illuminated as a result of bioluminescence—the production of light by ma-

rine animals and organisms. This theory is discounted for several reasons.

First, surface bioluminescence is normally a small-scale effect occurring as a result of agitation in turbulent waters, along beaches, and in the wakes of ships or around other obstacles in the sea (Sverdrup et al., 1942). The area shown illuminated in the Sea of Japan is a huge area under almost calm wind conditions, which would not favor a bioluminescent display.

Second, bioluminescence is most pronounced in the warmer waters of the world. The DMSP data indicate that the lighted areas are concentrated mainly on the cooler side (north) of the mixing

zone where the saury should be more abundant due to their predilection for cooler waters in the temperature range of 18°-20°C (Inoue and Hughes, 1971). Similar effects have not been observed by satellite in the warmer waters of the world where bioluminescence is commonly reported.

Finally, the intensity of bioluminescence, per unit area, is much less than that developed by the lighting systems of the saury fishing vessels. A bioluminescent effect, if visible, should appear more as a diffuse streak or diffuse area of rather limited extent than as a point source or series of point source concentrations of light, as revealed in the



Figure 4.—Saury fishing vessel (Inoue and Hughes, 1971).

DMSP data.

It is of interest that such a concentration of lights over the Sea of Japan is not commonly seen. Saury respond to allur-

ing lights only during a short period each year in the spring and in the fall (Inoue and Hughes, 1971). Lights were again noted in data acquired on the following

day (27 September 1974), but in diminished numbers as a strong tropical storm system moved northward toward Japan. They were not noted again in a perusal of selected data extending to early December 1974, although IR (infrared) data, at times, again revealed the presence of a strong oceanic frontal boundary.

Assuming that the results of this suggested fishing activity were positive, this example appears to offer rather dramatic evidence that meteorological satellites can be of great value in assisting the fishing industry through monitoring the location and changes in location of important oceanic convergence zones throughout the world.

ACKNOWLEDGEMENTS

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The ocean's yield of seafood depends on international cooperation. An integrated management system for salmon could be a beginning.

Toward a Planetary Aquaculture—the Seas as Range and Cropland

TIMOTHY JOYNER

THE OCEANS SEEN FROM SPACE

Views of the earth from orbiting satellites are changing our perception of this planet (Fig. 1). Images relayed by satellites show that the distribution of heat at the earth's surface is uneven, the result of dynamic processes. Heat transfer in the sea occurs by the slow, stately circulation of ocean currents; in the air heat is transferred by the wind. Heat transfer processes in the ocean and on the land produce the phenomena we call climate. These processes also affect the distributions of fresh water, soil, and vegetation on land and of salinity, nutrients, and marine life at sea.

To the observer from space, the earth appears as a microcosm, a fit subject for a garden. To live up to the responsibilities that go along with this expanded perception of our world, we must become planetary gardeners. For of all the skills developed in the course of our cultural evolution, none is more basic to our survival than gardening. The skill of the gardener lies in his knowledge of the kinds of plants and animals that will grow well on his particular plot and how to select the ones that will produce high yields for the least cost in energy and materials.

Among the many benefits to be derived from good gardening practice, not the least is beauty. Well designed and managed flower gardens, farms, and forests are among the most beautiful features of our planet. It is no accident that when and wherever civilizations have arisen, parks and gardens have been among the most widely appreciated forms of aesthetic endeavor.

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gardens of tropical fish hobbyists. No matter what the medium and the scale of the gardening, the same basic principles apply—the appropriate selection and location of crops and the conservation of energy and materials. If we regard the whole earth as a garden plot, we cannot ignore the seas in our development of a planetary garden design. We must learn to regard them in the agricultural sense as range and cropland to be carefully and lovingly husbanded rather than as a limitless source of freebooty.

Continuation of the nationally self-serving and often shortsighted methods now being used to exploit the world's fisheries will most certainly insure that the sea will never reach its potential as a reservoir of protein—protein sorely needed in a world increasingly beset with malnutrition and food shortages. What we most desperately need to do is to develop a rational system of planetary aquaculture through which we can

From bottle gardens to national parks, most of our garden designs have focused on dry land. Some notable exceptions, however, are the swamp gardens of the Aztecs, which provided immense yields of food crops; other examples are flower gardens in the mangrove swamps of South Carolina and Georgia, underwater gardens and parks in Florida and the Caribbean Islands and, on a smaller scale, the aquarium



Figure 1.—The earth from space (NASA photograph).

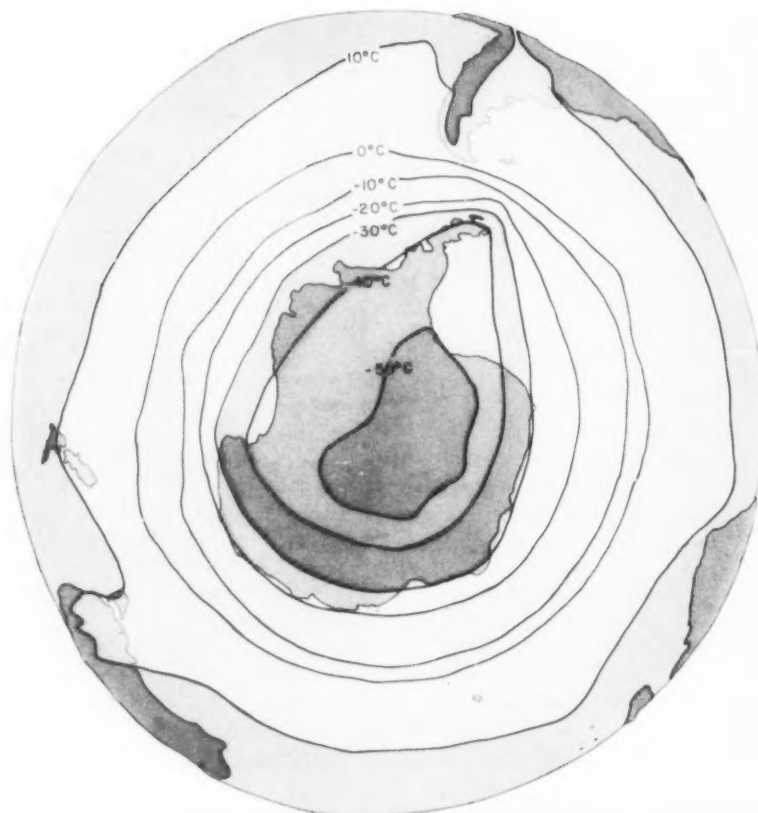


Figure 2.—Surface air temperatures—southern hemisphere, winter.

apply good, sound gardening sense and knowledge of the basic physical geography of our planet to the husbandry of our ocean resources.

The most heavily exploited parts of the world's oceans, the seas of the polar and subpolar regions, have suffered the most from destruction of valuable stocks of fish and marine mammals. What basic factors should we integrate with our good gardening sense to determine how we ought to be farming these cold seas? What crops will be best? How can we cultivate and harvest them with the lowest energy cost and the least damage to the environment?

COMPARISON OF THE POLAR HEMISPHERES

Because of the uneven distribution of land and water, the earth's hemispheres are distinctly different when viewed from points of vantage in space above the polar regions.

Viewed from above the Antarctic, the Southern Ocean surrounds the ice-

capped land mass in a nearly unbroken girdle. Only the tip of South America and a few minor islands penetrate the ocean south of lat. 50°S. As far north as lat. 40°S, Tasmania and the South Island of New Zealand are the only other significant land masses. In subantarctic regions, winds and ocean currents exhibit the simple patterns produced by the earth's rotation and latitudinal differences in solar heating (Fig. 2). They are little modified by irregularities in the earth's solid surface. The climate reflects the prevailing westward flow of wind and water and the nearly direct correspondence of temperature and latitude.

Quite a different view is presented to an observer above the Arctic regions. Land masses predominate, particularly in the sector between long. 120°W and 140°E. Differences in the absorption and radiation of heat by land and water and the deflection of winds by mountains and of ocean currents by bordering lands, all tend to complicate the patterns of weather and climate. In the Northern Hemisphere, these patterns

are twisted, stretched, and compressed in contrast to the smooth, concentric patterns of the Southern Hemisphere (Fig. 3).

DETERMINANTS OF PRODUCTIVITY

Organic production both on land and at sea depends on the same sources of energy and matter: light and heat, water, air, chemical nutrients, and seed. However, land and sea differ in the relative proportions of air, water, and solid earth interacting at their surfaces. On land, the solid earth and air are in contact everywhere and water is unevenly dispersed. At the sea surface, the principal interface is between air and water, and solids are unevenly dispersed. Fertility depends largely on the distribution of the dispersed phases. On land, it is highest in well-watered soils in river valleys and on old lake bottoms. Seawaters are most fertile wherever suspended and dissolved solids are concentrated near the surface by the action of currents. In both cases, nutrient chemicals derived from land are distributed by moving water to fertile areas where they become available to green plants. These, using the radiant energy of the sun, produce the organic matter upon which all life on earth ultimately depends. For organic production to occur, however, seed must be available, appropriately matched to local conditions. Without it, even the most fertile area cannot produce the balance of organisms needed equally by natural ecosystems and well designed gardens.

RANGE AND CROPLAND

Classifying marine environments in basic agricultural terms would seem an appropriate early step toward the development of a rational system of planetary aquaculture. In agricultural terminology, the oceans would be comparable to open range. Coastal waters and continental seas are generally subject to the jurisdiction of the bordering nations and are more amenable to intensive resource management. They can be reasonably likened to cropland. Public ownership on the high seas, however, would represent global interests rather than the national ones that prevail in most land areas with the exception of Antarctica. Private interests in coastal waters would properly encompass those of nations and states as well as of

corporations and individuals. In basic agricultural terms, then, the seas of the world would be classed either as ocean ranges or coastal croplands.

MANAGEMENT

Ocean ranges might be recognized as global common property with management responsibility vested in an international regulatory body. The right to exploit the resources of the ocean ranges could then be leased to responsible applicants much as publicly-owned range land in the United States is leased to livestock growers. Appropriate charges could be assessed against the lessees. The proceeds could then be used to sustain management programs designed to protect and enhance the productivity of the ocean ranges, and to insure distribution of their benefits to best serve the interests of the global public.

Coastal croplands could be managed by the coastal states according to their special customs and interests. If their management practices could be shown to benefit stocks that are harvested on the high seas, responsible coastal states could be credited for appropriate shares of the value of the high seas harvest that would be proportional to their contribution.

For migratory stocks, such as salmon, that return from the ocean range to coastal rivers, the coastal states should have the exclusive right to harvest. To support international management of the high seas, however, they might be charged a portion of the value of the catch for use of the ocean range where their salmon fatten and grow to maturity. It does not make good sense to expend precious supplies of energy by sending boats out to net salmon at sea. Given the opportunity, salmon will return to their native rivers to spawn. There they may easily be caught in traps where they can be kept alive. With this kind of harvest, it would be relatively simple to keep appropriate inventories of fish returning to each coastal stream and to release enough to insure sufficient seed for the next generation. Caught from boats fishing out at sea with gillnets, salmon are generally dead or severely injured when brought aboard. Harvested in this manner, it is seldom possible to determine in what stream they would have spawned and impractical to release part of the catch unharmed to insure sufficient produc-

tion of seed. Management of such a fishery is difficult and its results inherently uncertain. Shore fisheries using traps managed by the coastal states and not subjected to high seas net fishing would provide a much more efficient way to sustain a maximum harvest of salmon.

CHOOSING THE CROPS

The development of agriculture has spanned thousands of years. Nevertheless, the species cultivated as major crops are few relative to the number of wild species that have survived to the present day. Goats, sheep, pigs, and cows were domesticated in that order and became our basic livestock. Chickens, ducks, geese, and turkeys became the basic domestic fowl. Wheat, barley, corn, and rice became the staple grains of tropical and temperate regions. Oats, rye, and millet were better adapted to colder regions. There is no reason to believe that the cultivation of sea crops will not also be restricted to a

relatively few, easily managed, readily transplanted species.

Salmon, of all marine species, seem to offer the best prospects for early development of an aquacultural system capable of taking advantage of the natural productivity of ocean ranges. The reasons for this are:

1. The vulnerable, early stages of development are spent in fresh water. Relative to the open sea, this environment is both accessible to and can be protected by man.
2. There is already available a considerable body of knowledge about the life history of salmon and a proven hatchery and nursery technology that can be applied to a rational system of management.
3. After they migrate to sea, the far-ranging salmon can efficiently seek out productive feeding grounds.

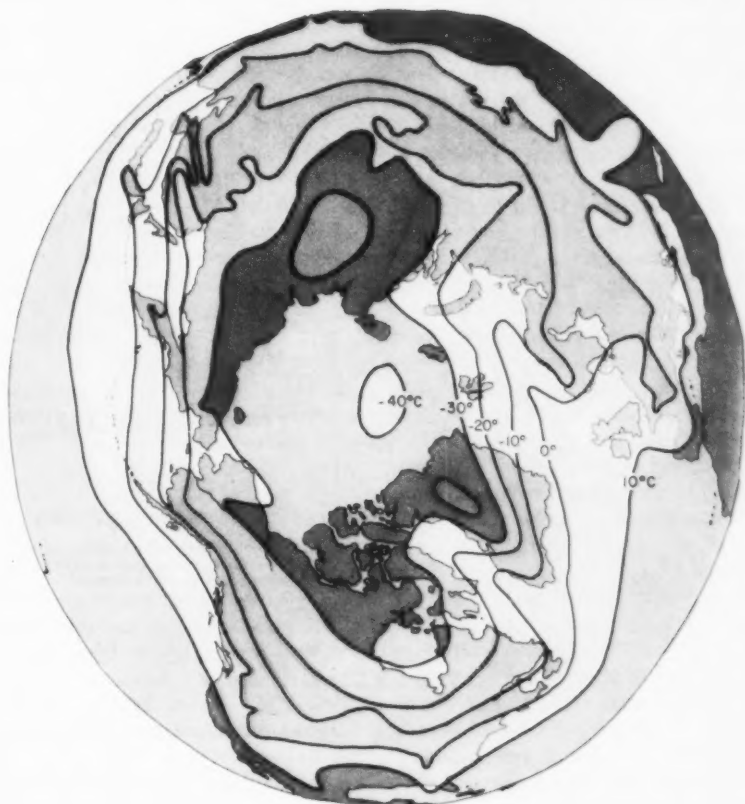


Figure 3.—Surface air temperatures—northern hemisphere, winter.

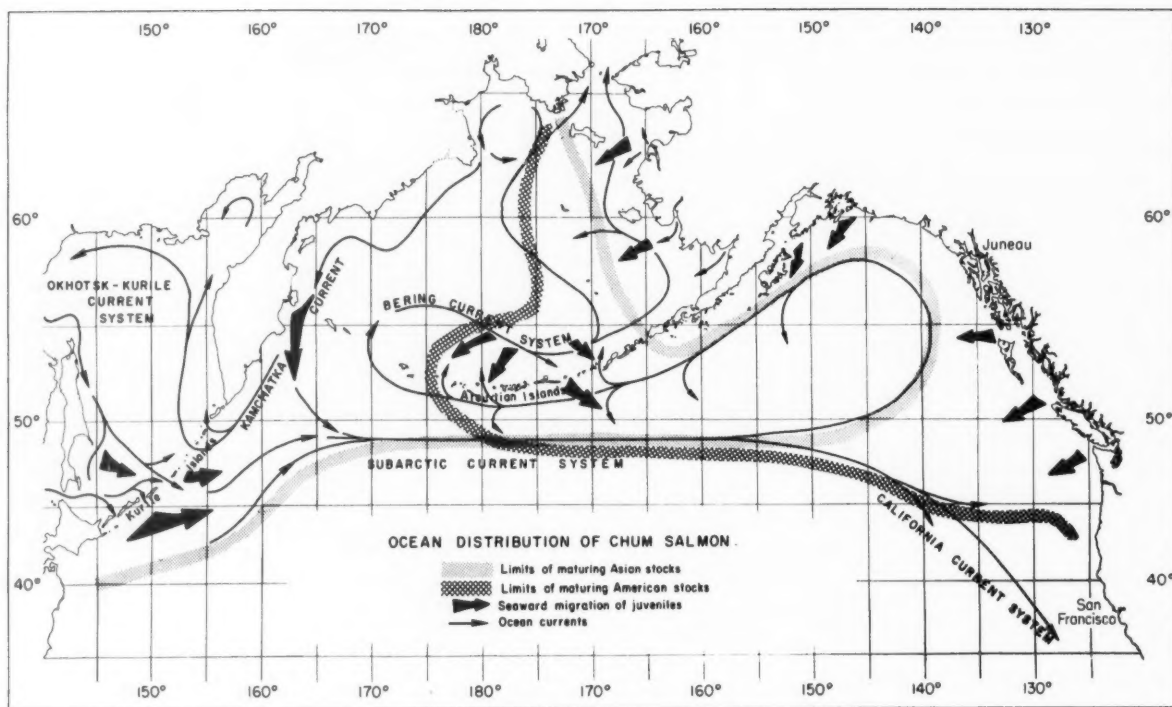


Figure 4.—Ocean distribution of chum salmon.

4. After fattening for several years at sea, salmon return to their native rivers without having to be herded. There they may be easily harvested with traps at a very low energy cost.
5. The fecundity of salmon is high—a single pair will produce thousands of offspring—and the rate of growth is rapid.

Given these characteristics, it would seem prudent to phase out offshore gillnet fishing in favor of catching salmon as they enter their home streams to spawn. Using live traps wherever feasible, this would provide not only a simple, efficient, easy-to-regulate way to harvest but, combined with artificial propagation to mitigate the loss of spawning areas, could also become a powerful tool for rebuilding depleted stocks. Admittedly, this would be at the expense of the high seas gillnet fishery, but it would serve better the interests of the consuming public by making possible the rational management of one of its major fishery resources. The salmon resource has proved vulnerable both to degradation of spawning areas in the coastal rivers and to the effects of high

seas gillnet fishing. Indeed, when Atlantic salmon stocks, already so seriously depleted by the effects of urban and industrial development that they had disappeared from most of the major rivers of western Europe and the northeastern United States, were subjected to intense offshore fishing in Greenland waters in the 1960's, it appeared that many of the remaining stocks were being threatened with extinction. Fortunately, in 1972, the International Commission for the North Atlantic Fisheries (ICNAF) approved an agreement that was subsequently ratified by the Danish parliament to phase out the Greenland offshore salmon fishery. Great Britain, the United States, and Canada have banned, and Ireland has restricted, offshore net fishing for salmon to their fishermen. Norway still permits an offshore fishery in the Norwegian Sea.

Although the Pacific salmon have not yet been as severely depleted as the Atlantic species, the combination of freshwater habitat destruction and intensive high seas fishing have taken their toll. The total catch of all species by all nations, which peaked during 1934-43 at an average of 712,000 metric

tons annually, declined by one-third to an average of 478,000 metric tons for 1960-71.

The native fishing peoples around the rim of the Pacific Ocean, from Northern Japan to California, who were regarded as primitive by the invading bearers of civilization, generally entertained a deep reverence for salmon and had fished for them with weirs and traps for thousands of years. Sensible harvesting customs, built into the very fabric of their cultures, recognized the value of restraint in the capture of this precious resource. By learning to use the wisdom and restraint employed by these ancient cultures in harvesting, and by thoughtful application of appropriate modern technology to salmon husbandry, it should be possible to restore and eventually even to exceed the abundance that once characterized the resource.

With the many conflicting national interests of maritime states, an effective international management system for the exploitation of the living resources of the high seas will have to be developed. Our ability to sustain and distribute fairly the ocean's yield of sea food to the world's markets will depend largely on agreement between nations

on the extent of national jurisdictions and access to common property resources at sea.

Taking one step at a time, it would seem that establishing an integrated management system for the salmon fisheries could serve as a reasonable first step toward general international management of ocean resources and as an early model for the development of a planetary aquaculture.

There are already in force multinational agreements for the protection of both Atlantic and Pacific salmon, instituted primarily at the insistence of the coastal states that are making serious efforts at conserving and rebuilding their native stocks. In 1952, a treaty was negotiated between Canada, Japan, and the United States that required Japan to abstain from fishing for salmon east of long. 175°W. Canada and the United States do not permit their fishermen to take salmon on the high seas. In 1956, Japan and the USSR negotiated a convention that prohibits Japan from salmon fishing along the Kurile-Kamchatka coasts and in the Sea of Okhotsk; it also subjects Japanese fishermen to annually determined quotas west of the abstention line at long. 175°W. The ICNAF Convention of 1972 has undertaken to phase out the Greenland fishery for Atlantic salmon. These multinational agreements indicate a trend toward the elimination of high seas net fishing for salmon. If high seas fishing nations lacking sufficient coastal access to the salmon resources could be assured of reasonable commercial access to the salmon markets, complete phaseout of salmon fishing on the high seas could become a realistic objective of international ocean resource management.

STOCKING THE OCEAN RANGE

Assuming that international regulations ultimately will be able to protect salmon from high seas net fishing, we must consider how to stock the ocean ranges to insure optimum yields. Wherever possible, pollution abatement and restoration of natural spawning areas will have to play a continuing role in building back the depleted stocks. Where this is not possible and the streams and rivers where salmon once spawned have been irreversibly

changed, hatcheries can be built to restore some of the lost capacity to produce salmon. Although hatchery production cannot reasonably be expected to match that of extensive natural spawning, the survival of eggs and fry in efficient, well located hatcheries and nurseries often greatly exceeds that of natural systems. Development of fishways to make areas of streams hitherto unavailable for spawning accessible to salmon and the seeding of virgin areas can also be used to stock the ocean ranges.

Islands such as the Aleutians and the Kuriles in the Pacific and Iceland in the Atlantic, that lie athwart the routes that salmon travel on their way to their feeding grounds, are strategically located for injecting salmon into the ocean ranges (Fig. 4). Being volcanic, these islands are potential sources of geothermal energy that could provide heat and power for operating efficient, temperature-controlled fish rearing facilities. From these island bases, selected stocks of salmon could be released where currents would carry them quickly to the ocean feeding grounds. By using temperature to control the rate of development while the salmon were being reared in fresh water, it would be possible to stagger the releases of the cultured stocks so that the harvest of returning adults would be spread over a convenient period.

SEEDING THE SOUTHERN OCEAN WITH SALMON

Bounded on the north by the Subtropical Convergence near lat. 40°S, and on the south by the ice-covered mass of Antarctica, strong westerly winds drive the waters of the Southern Ocean continuously eastward in a current known as the West Wind Drift. These waters provide an environment that should be favorable for the oceanic part of the life cycle of salmon. Water moving upward from intermediate depths inside the Antarctic Convergence brings to the surface nutrients dissolved from decaying marine organisms and from glacial flour dropped by melting ice. These currents are carried northward to the region of the Convergence (generally between lat. 50° and 55°S) by cold surface waters flowing outward from Antarctica. Small, shrimplike crustaceans, called krill, that would be excellent

feed for salmon abound inside the Antarctic Convergence. Particularly dense concentrations are found in the Scotia Sea to the southeast of Tierra del Fuego.

Just inside the Antarctic Convergence where dense concentrations of krill begin to appear, the range of water temperatures is from about 5° to about 2°C. Such a regime would favor Arctic races of chum, sockeye, and pink salmon. If stocks of these species were planted in suitable streams at the southern end of South America where it projects into the West Wind Drift, the migrating smolts should have little difficulty in finding krill. They simply would have to swim down the temperature gradient until they reached the nearby Antarctic Convergence. Those moving randomly in the current would be swept eastward around the globe in about 2 years, approaching the South American coast from the west as they completed each circuit. Others would probably stay in the dense krill concentrations of the Scotia Sea. In either case, the flow of Andean runoff into the West Wind Drift should lead them readily back to the continent and the streams where they were spawned.

In the short Antarctic food chain, baleen whales have been the principal foragers of krill. Overfishing has now brought these slow breeding mammals to the verge of extinction, and vast populations of krill remain uncropped. Fishery scientists from the USSR have estimated that Antarctic waters could support a krill fishery that could yield annually in excess of 100 million tons, nearly double that of all the rest of the world's fisheries combined. Experimental fishing for krill from research vessels of the USSR and Japan has shown that the energy cost of such a fishery would be very high. It takes a lot of fuel to drive a fleet of large fishing vessels half way around the world and to drag large, fine-meshed nets through rough water in the foul weather that usually prevails in that part of the world.

On the other hand, if appropriate races of salmon could be established in Antarctic waters, they should be able to hunt the krill efficiently and to convert them into an easily accessible, highly nutritious, and readily marketable product. A sensibly managed salmon fishery in the Southern Hemisphere should be both aesthetically and ecologically preferable to fishing for whales. It

should also be an economically desirable alternative to the development of an expensive high seas krill fishery. Development of a successful salmon fishery in the Southern Hemisphere will require extensive international cooperation. Seed stocks and technical and economic assistance will have to be provided to help the countries with the appropriate land and freshwater resources develop the necessary rearing, harvesting, processing, and marketing facilities. Agreements to prevent dis-

tant water fishing fleets from taking the newly introduced salmon stocks on the high seas would have to be developed. However, because the new fishery would be developed in virgin territory, the lack of established fishing practices, customs, laws and special interests relating to salmon should make it less difficult than in the Northern Hemisphere to achieve the international cooperation necessary for developing a rational system for managing the new resource.

Creation of a new, internationally-managed, open range salmon fishery in the presently underutilized waters of Antarctic seas could produce a significant stimulus for further international cooperation in the sensible development and equitable distribution of the untapped wealth of the oceans. It most certainly would lead us a step away from the plundering of the seas so that we may become instead of the pirates that we have been, the gardeners of our planet.

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A profitable and rapidly growing industry is examined.

An Economic Analysis of Georgia's Marine Charter Boat Fishing Industry

E. EVAN BROWN and FRED J. HOLEMO

INTRODUCTION

Since the end of World War II, outdoor recreation has been appealing to more and more Americans. In 1965, the Bureau of Outdoor Recreation predicted a fourfold increase in participation of summertime outdoor recreation activities between 1960 and the year 2000 (Anonymous, 1967). Because of this projected increase in outdoor recreation it is reasonable to expect the demand for marine charter boat fishing to also increase.

In confirmation of the above statement regarding expected growth of marine charter boat fishing activities, it was found that the Georgia charter boat fleet increased from 8 to 17 in 4 years (1970-1973).

Although the existing number of charter boats in Georgia is small and thus such activities might be considered negligible, data from other States indicate that nationwide the economic effects of marine charter fishing are very large.

For example, Parke H. Young, of the California Department of Fish and Game, showed that at the beginning of the 20th century the party boat industry in California was composed of a few boats that catered mainly to wealthy individuals (Young, 1969). Thirty years later a nucleus of the present fleet of about 400 party boats¹ was forming. Today in California party boat fishing is enjoyed by individuals in all income classes. During 1947-1967, the California marine party boat fleet reported a catch of over 71 million fish with annual totals ranging from 2.0 to 5.4 million.

¹Party boats (head boats) are operated by selling tickets on a per head basis to any individual who desires passage. A charter boat rents to a particular individual or group.

California's sport and commercial fishing industries were compared in a report presented to the State of California Resources Agency by Gruen Gruen and Associates (1972). The report contained estimates of the net economic value of fish resources under sport and commercial exploitation. It indicated that sport fishing contributes more to California's economy than commercial fishing. The totals are \$100-\$200 million for sport fishing as compared with \$45 million for commercial fishing. The report also pointed out that the secondary income effects of sport fishing (\$300-\$400 million) are larger than those of commercial fishing (\$200-\$300 million).

A study recently completed by Hart (1972) deals with the charter and head boat fishery in Morehead City, N.C. Significant direct and indirect contributions to the net income of Carteret County residents resulted from expenditures in Morehead City on commercial charter fishing services by nonresidents.

According to John A. Guinan, formerly NOAA Public Affairs Officer for the National Marine Fisheries Service (NMFS), "There are about 9.5 million sports fishermen who seek marine fish," (Guinan, 1973, p. 36). Many of these fishermen charter boats.

The food value of marine fish caught by all marine sport fishermen is revealed by a statement by Robert W. Schoning,

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Director of NMFS. He stated that fish caught by marine sport fishermen is nearly two-thirds of the commercial catch (Guinan, 1973, p. 36). The amount of money spent while catching these fish is far in excess of the dollar value of the fish caught.

PROCEDURE

During the spring of 1973 a search was conducted for publications listing the names and addresses of marine charter boat operators in Georgia. This search yielded no results. Unlike South Carolina and Massachusetts, but like many other States, Georgia does not have a publication containing this information (Anonymous, 1970, 1973).

Since there were no leads as to how to obtain a listing of operators, it was decided to employ the same technique used in South Carolina in developing its charter fishing guide (Anonymous, 1973). The technique involved personal interviews with the best known operators in each of the State's charter fishing areas. At the end of each interview these operators were asked for the names and addresses of fellow charter boat operators. The list progressed until no new names were added. Thus it was assumed that this list contained the names and addresses of the entire population of marine charter boat operators fishing from Georgia ports. Included were operators residing in Georgia and other States but operating only from Georgia ports. The list does not contain the names of operators living in Georgia and operating from ports outside the State. Every operator on this list was interviewed and the desired information was secured.

RESULTS AND DISCUSSION

It was found that the 17 charter operators had three primary fishing areas. These are: 1) artificial reefs (offshore), 2) Blackfish Banks and Sapelo Reefs, and 3) the Gulf Stream.

Sixteen of the operators had gasoline- or diesel-powered boats, while one operated a large sailboat. The educational levels of charter operators was high, with only one operator not having a college or high school diploma. Fifteen of the 17 operators had other means of support in addition to their charter income.

Table 1. Expected yearly costs and returns for a representative charter boat operation in Georgia (initial capital investment = \$28,883; 812 charter hours).

Item	Dollars
Gross Returns	18,830
Costs	
Fixed costs	7,779
Depreciation	1,027
Interest	2,888
Taxes	265
Insurance	588
Docking	601
Battery	44
Rope	22
Tackle	212
Advertisement	44
First Aid	5
Repairs	1,794
Miscellaneous costs	289
(1% of initial capital investment)	
Variable costs	5,943
Tackle (replacement)	174
Bait	143
Hired labor	1,437
Fuel	2,875
Oil, fluid, grease, filters	121
Ice	210
Repairs (due to use)	983
Net return to management and labor	5,108

Because much of the time spent aboard by charter passengers is spent riding to and from fishing areas, the vessels are well equipped. Most of them had such comfort items as air conditioning, sofas, carpeting, television, and stereo. All vessels had ship-to-shore communications and one-half had a loran navigational device.

The Georgia charter boat industry is relatively new. The oldest operation has been in business only 19 years. During the past 5 years only one operator has ceased operations while slightly more than one-half began operations during the past 3 years.

Main species fished for are marlin, dolphin, sail, wahoo, king mackerel, black sea bass, Spanish mackerel, and cobia. Other species caught are considered to be incidental.

Table 2. Expected yearly averaged costs and returns for the three most profitable marine charter boat operations in Georgia, 1972 (initial investment = \$29,352).

Item	Dollars
Gross returns	40,083
Costs	
Fixed costs	8,123
Depreciation ¹	963
Interest ²	2,201
Taxes	259
Insurance	1,049
Docking	642
Battery	50
Rope	27
Tackle	527
Advertisement	7
First Aid	5
Repairs	2,100
Miscellaneous	293
(1% of initial capital investment)	
Variable costs	5,586
Replacement tackle	292
Bait	350
Hired labor	521
Fuel	3,972
Oil, fluid, grease, filters	239
Ice	212
Net return to management and labor	26,374

¹Average annual depreciation = $\frac{\text{Initial cost} - \text{Estimated salvage value}}{\text{Estimated years of useful life}}$.

²Average annual interest = $\frac{\text{Interest rate (initial cost plus estimated salvage value)} \div 2}{1}$.

The average net income for the average charter operation was moderate, amounting to \$5,108 annually (Table 1). However, it should be recognized that 15 out of 17 operators did not rely upon net charter income for their entire living. In 1972, the representative charter boat cost \$28,883. Annual gross income was \$18,830 while annual costs were \$13,722. These figures were based on chartering 812 hours. Break-even costs were \$17 per hour. These data include all 16 gasoline and diesel driven boats available for either non-Gulf Stream or Gulf Stream fishing trips.

Additional cost and return data are shown in Table 2. These data are for the three most profitable marine charter

boat operations. The only real significant difference between these three operators and the average operator was in number of hours chartered. The three most profitable operators chartered an average of 1,241 hours annually compared with 812 hours for the average operator. The additional hours lowered the break-even cost from \$17 to \$11 per hour. The average net return to management after all expenses for these three top operators was \$26,374 annually.

None of the charter operators kept any records of total pounds of fish caught. Hence comparisons with the Georgia commercial catch are not possible. What is significant, however, is the growth experienced by the embryonic (compared with California) Georgia charter fleet in recent years. Also significant were the statements by two-thirds of the operators that the interest in and number of hours chartered were increasing.

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Observed and Perceived Impacts of Distant Water Fishing: Oregon Otter Trawl Case

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ABSTRACT—*Distant-water fleets appeared off the Oregon coast in 1965. Change in the growth, equity, and diversity of Oregon otter trawl landings between 1965 and 1972 indicated that the observed well-being of otter trawl fishermen did not change significantly. Fishermen, however, perceived the foreign competition as a significant threat to their industry.*

INTRODUCTION

Distant-water fishing fleets are operating off the coasts of most nations. One of the issues to be worked out in international conferences is the rights of local and international fishermen to fisheries of the continental shelf. In most cases distant-water fleets are larger, better equipped, and take a larger share of the resource than local fishermen, and this results in a feeling among local fishermen of being disadvantaged. Very often, however, local fishermen blame problems on distant-water fleets which require regional and national solutions directed at people's perceptions, priorities, and cultural tastes.

One case which fits this category is the Oregon otter trawl fishery. Local fishermen perceived that distant-water fleets operating in the region had severely diminished their fishery. Observation of changes in the fishery during the period 1965-1972 indicated that the distribution of catch among otter trawl fishermen had not changed significantly. Open entry was a local problem partly responsible for the lack of growth experienced by the fishermen in the fishery. In addition, a look at national priorities and at the consumption patterns of people in the United States showed fishing lacked recognition as

being important in food production. While these conclusions are not to diminish the impact of distant water fleets on local fisheries, they do suggest that even rapid and favorable results from international conferences may not bring relief to local fishermen.

OREGON OTTER TRAWL FISHERY

Since 1965 Soviet trawlers have been fishing off the coasts of Oregon and Washington. These trawlers compete with otter trawl fishermen for some species of groundfish, e.g. sole and other flatfish, Pacific Ocean perch, and other rockfish. The Oregon Otter Trawl Commission has maintained data on the gross value of landings for Oregon licensed vessels since 1964. No causal link can be established between the appearance of distant water fleets and measures of the well-being of Oregon otter trawl fishermen, but if the competition directly or indirectly affected commercially valuable species, this result should be observed in the value of otter trawl landings, unless other factors had a compensating effect.

Observing change through time in the shape of a frequency distribution of the value of otter trawl vessel landings gives a gross indication of well-being. Change through time in such descriptive statistics as the average, skew, and kurtosis are indicators of growth, equity, and diversity. Growth measures increase or

decrease in the value of landings. Equity and diversity indicate changes in the distribution among otter trawl vessels. Equity measures distortion, and diversity measures the degree of concentration.

Growth was measured by evaluating the change in the average gross value of landings per otter trawl vessel per year. The average values were regressed as a function of time and the slope of the regression line was used as an indicator of growth (Fig. 1 and Table 1). A positive slope to the regression indicates growth, a negative slope, decline. For the period 1965 to 1972 the average gross value of landings per vessel increased at a rate of 2 percent per year. Correcting this for inflation during the period and re-evaluating the slope of the regression line showed decline at a rate of 3 percent per year.

This approach to evaluating growth overlooked the possibility that growth was due to changes in the number of vessels. The number of vessels increased from 66 in 1965 to 109 in 1972, and the total value of the catch increased from \$1.9 to 3.6 million.

Another concern is the use of gross value of landings per vessel as a measure of well-being. From an economic view, net profit or returns to labor and capital would be better measures. The question, however, was about the point of view of fishermen in relation to observed changes. While there are certainly better measures of well-being, the measure used had to bear a relation to the perceptions of fishermen.

Most of the fishermen interviewed¹ did not share the economic view of how their well-being should be figured. Fishermen tended more to evaluate their success by the quantity of fish caught. As one fisherman stated, "The true fisherman does not figure money. He figures catch and the money takes care of itself." After quantity the next most common measure of fishing success, in the fishermen's view, was gross income. Gross income is the product of the quantity of fish caught times the price paid. Between 1965 and 1972 the average prices paid for otter trawl catch

¹Data on fishermen's attitudes came from observation of their behaviors, review of published statements, meetings, and open-ended interviews with 120 Oregon commercial fishermen from 1 July to 30 December 1972. These commercial fishermen fished salmon, albacore, crab, shrimp, and ground fish.

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did not change significantly. For comparison between observed and perceived well-being, gross income provided a unit of measure comparable to the way fishermen evaluated their success.

For equity, the skew in the distribution of the annual per-vessel value of

otter trawl landings was calculated and regressed against time. A progressively positive skewing of the distribution would indicate that fewer fishermen were doing very well while more were doing poorly with regard to the distribution of catch. The slope of the regression line for skewing plotted against

Table 1.—Oregon otter trawl fishery.¹

Year	No. Vessels	Growth		Equity	Diversity
		Uncorrected \$/Vessel	Corrected \$/Vessel	Skew	Kurtosis
1972	109	33,180	25,000	0.80	2.9
1971	94	30,800	23,970	0.69	2.7
1970	99	28,610	23,220	0.69	2.6
1969	83	25,420	21,860	0.34	2.0
1968	80	30,180	27,360	0.45	2.3
1967	72	28,240	26,670	0.96	3.5
1966	64	26,650	25,900	0.84	3.4
1965	66	29,095	29,095	0.69	3.8
Slope of regression		544	-645	-0.01	-0.15

¹Source: Data provided by the Oregon Otter Trawl Commission. Corrected \$/vessel based on change in consumer prices in U.S. Bureau of Labor Statistics, 96 Monthly Labor Review 112(1973). For the regression models fit is not significant, and no relation with time can be demonstrated. These conclusions are expected, since time is used to indicate pattern. Lack of significance and the absence of a relation with time do indicate that the pattern observed is not fixed and can be expected to change.

time showed no change (Fig. 1 and Table 1). The average was +0.7, indicating a slight tendency in the direction of a few fishermen being very well off while the majority were doing poorly. These data indicate that inequities in the value of per vessel otter trawl landings did not change significantly during the period of competition from distant water fleets.

Diversity took the kurtosis for the frequency distribution and evaluated its change over time. Kurtosis measures the peakedness of a distribution. A very peaked distribution indicates concentration toward a single pattern of well-being. A platykurtic, broad curve, indicates more diversity. Kurtosis measured for otter trawl vessels between 1965 and 1972, indicated a slight increase in diversity. Kurtosis declined from just over 3.0 at the beginning of the period to just under 3.0 at the end of the period (Fig. 1 and Table 1). The increase was at a rate of 5 percent of the average per year and was not significant.

These data indicate that during the period analyzed per-vessel landings observed in the Oregon otter trawl fishery did not change significantly in terms of growth, equity, or diversity. This analysis does not mean that the distant-water fleets had no impact. The Pacific Ocean perch landings in Oregon dropped from over 5,900 metric tons in 1965 to less than 450 metric tons by 1969². This decline was attributed to

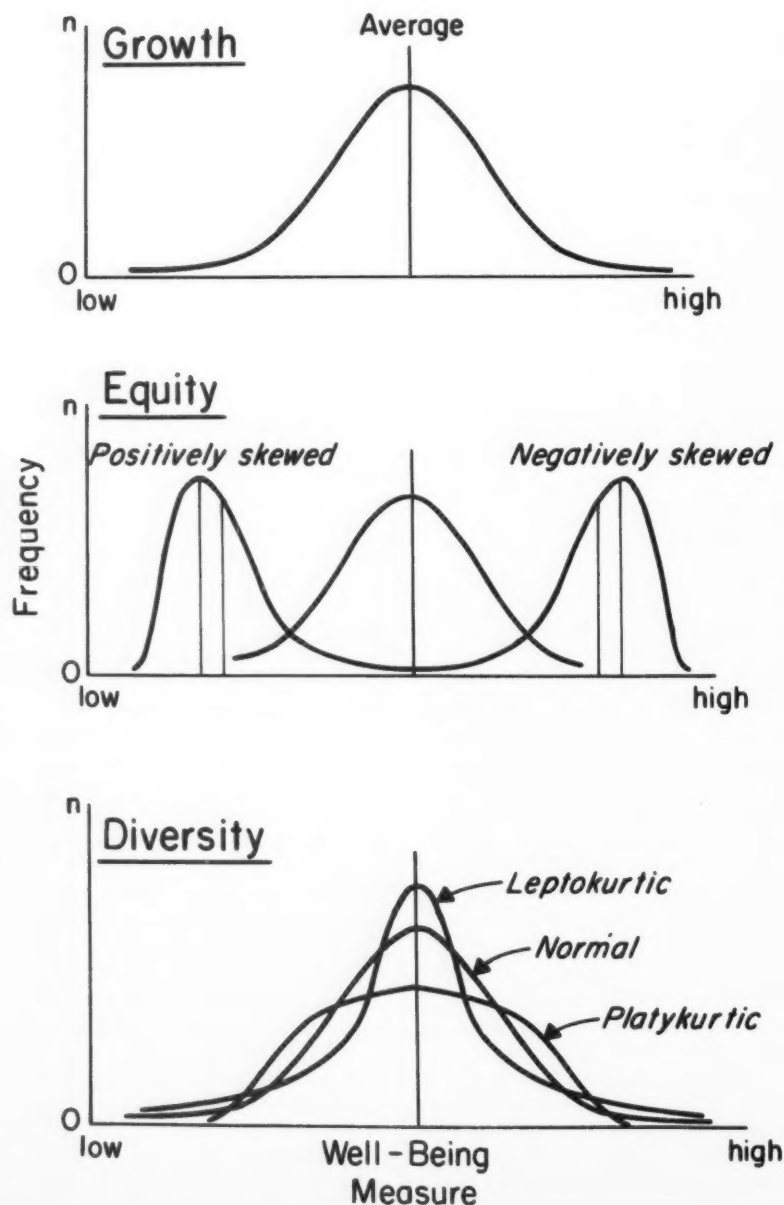


Figure 1.—Well-being indicators. Growth is change in the average through time, equity is change in skewedness, and diversity is change in kurtosis.

²Fish Commission of Oregon, Biennial Report, 1968-70 (1970).

distant water fishing effort. By exploiting other groundfish resources, the per-vessel landings of otter trawl fishermen did not experience the same decline. Instead, shifts occurred in the relative importance of the species harvested. For example, during the 1965-1972 period, a sevenfold increase in Oregon shrimp landings occurred. The number of otter trawl vessels harvesting shrimp increased from 24 to 67.

Even though these data did not indicate significant change in the observed well-being of otter trawl fishermen, the fishermen's perception of the situation was very different. They perceived the intrusion of foreign vessels as the most critical problem facing their fishery. Most felt betrayed by their government for not having kept "the foreigners off our fish." Many had a very pessimistic view for the future.

Why were distant-water fleets perceived as a threat to the fishery? Pursuing this question in depth with fishermen generally resulted in their pointing to the low priority the government gave to commercial fishing. The failure to do something about distant-water fleets which were "taking our fish" was one indicator to many fishermen of their low priority. In some contexts this low priority was actually verbalized by government officials. Fishermen were told that ocean priorities were national security, seabed mineral exploration, and ranked third was fisheries.

Statements and inaction told fishermen where they stood. Fishermen's perceptions reflected their frustration at not being recognized as important by policy makers. Otter trawl fishermen felt that the distant-water fleets had adversely affected the potential for growth. The data, however, showed an increase in otter trawl vessels from 66 to

109 between 1965 and 1972. Gross earnings from the fishery increased at an average rate of eight percent per year. The failure to realize the growth potential did not appear to be as much a consequence of the distant water fishing effort, but was the result of the influx of more otter trawl vessels.

Added to the problem of low priority and more otter trawl vessels was the place of fish in the consumption patterns of people of the U.S. While each fishery has specific markets it supplies, the overall implications of Table 2 are ines-

Table 2.—Per capita consumption fish and beef¹.

Year	Fish lb/capita	Beef lb/capita
1970	11.4	113.7
1960	10.3	85.1
1950	11.8	63.4
1940	11.0	54.9

¹Source: U.S. Department of Commerce, 93 Statistical Abstract of the United States 84 (1972).

capable. Beef consumption more than doubled during the period 1940-1970. Per capita fish consumption remained constant and declined from one fifth to one tenth the quantity of beef consumed. Certainly the argument can be made that with population growth the total demand for fish increased in spite of constant per capita demand. The implications of the decline in the relative importance of fish with respect to beef in U.S. consumption patterns, however, has wider implications. In policy decisions greater concern is given to those industries which produce the major portion of people's food requirements.

CONCLUSIONS

International law of the sea is but one aspect of problems facing local fishermen. Other aspects to the problem requiring regional and national attention

are the relation between fishermen's perceptions and observations of the local situation, the quantity of resource available, and the relative priority of fishing in policy making and consumption patterns.

Clearly limited entry programs represent regional attempts to solve some of these problems. These programs if properly designed and implemented can improve the livelihood of fishermen and reduce the cost of fish to the consumer, making fish more competitive with respect to other foods. Here again, however, the perceptions of local fishermen are sometimes at variance with the observations of economists. Fishermen are concerned with opportunities for their children; they believe in free enterprise; and they reject not allowing others to have an opportunity to make a living.

Changes in the international law of the sea and limited entry cannot solve the problems faced by local fishermen. At the heart of their problems are fishermen's perceptions and peoples' priorities and tastes. Without accompanying dramatic social and cultural change to accompany legal and economic proposals the net result may be very little total gain.

ACKNOWLEDGMENTS

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*Irradiation of
shrimp extends
their storage life.*

Low Level Ionizing Radiation and Spice Treatment of Raw, Headless, White Shrimp

A. N. ROY and J. D. KAYLOR

ABSTRACT—A study was made to determine the storage life of raw, headless, white shrimp treated with ionizing radiation and shrimp treated with turmeric and salt and ionizing radiation. Sensory assessment of irradiated shrimp and shrimp treated with ionizing radiation and turmeric and salt exhibited a storage life of 2 and 4 weeks longer, respectively, than nonirradiated shrimp. The spice treatment masks off-odors and flavors caused by irradiation and imparts a spicy odor, inhibits melanosis, and produces a more desirable irradiated product.

INTRODUCTION

A review of the literature of the past decade dealing with low-level irradiation treatment of fish and shellfish shows that the refrigerated storage life is increased (Miyauchi et al. 1967-1968, Slavin et al. 1966, Ronsivalli 1967, Kumta and Sreenivasan 1967). In such studies, irradiation doses ranging from 50 kilorads to 1 megarad followed by refrigerated storage have been used (Coleby 1959). Spoilage bacteria are eliminated effectively and selectively by low-level doses of irradiation, thereby resulting in extension of storage life (Masurovsky et al. 1963, Pelroy and Eklund 1966, Laycock and Regier 1970). Considerable work has also been done to extend the storage life of fishery products even further by irradiation in combination with other chemicals such as sodium benzoate (Lee et al. 1965) and antibiotics (Awad et al. 1965) through synergistic bactericidal effects. Spoilage of the product finally ensues when some bacteria survive such treatment, multiply, and finally degrade fish tissue.

When fish and meat are irradiated at different dose levels, radiation-like odors and flavors are more pronounced at higher dose levels (Urbain 1965, Hannesson and Dagbjartsson 1970), but the intensity of the odors and flavors

diminishes as the storage period lengthens (Scholz et al. 1962).

In India and other far eastern countries, people are accustomed to eating spiced food. Many such spices are known to possess antioxidant and tinctorial properties apart from conferring their characteristic odor and flavor to foods. Thus, Sethi and Aggarwal (1950) found that chili peppers, cinnamon, ginger, turmeric, nutmeg, black pepper, and cloves retarded rancidity in peanut oil.

Although some work has been done on the development of radiation-sterilized fish and fishery products by masking with spices and seasonings (Waters et al. 1969), practically no work has so far been reported on the use of spice in combination with low-level irradiated fishery products for inhibiting bacterial spoilage. Since turmeric is

popularly used with salt in India for nearly every fish dish, it would be desirable to use it to mask any irradiation off-odor and off-flavor that might be developed during irradiation processing even at low doses. The present investigation was made, therefore, to study the feasibility of combining low-dose ionizing radiation of shrimp with turmeric and salt as a preservative process.

MATERIALS AND METHODS

Fresh, headless, white shrimp, *Penaeus setiferus*, of commercial size (26 to 30 count) caught in Florida waters were air-shipped in ice in an insulated container to Gloucester, Mass. The shrimp were divided into different lots as control, pretreated control, irradiated, and pretreated and irradiated. The pretreatments were as follows:

- I. 5% suspension of turmeric spice - 15 minute dip.
- II. 5% suspension of turmeric spice - 30 minute dip.
- III. 5% suspension of both turmeric and salt - 15 minute dip.
- IV. 5% suspension of both turmeric and salt - 30 minute dip.

The samples (approximately 100 grams each) were then air-packed and sealed in heat-sealable polyester film bags and irradiated immediately under refrigerated conditions (42°F) at 100, 200, or 300 kilorads and held at 33°F for subsequent storage study. Since detectable irradiation off-odor and off-flavor in shrimp has been established as occurring above 250 kilorads (Kumta et al. 1970), a maximum irradiation dose of 300 kilorads was included so as to determine their occurrence in this study.

Sensory evaluation and bacteriological tests were performed periodically on the refrigerated stored samples. The sensory evaluation test was carried out using a 9-point hedonic scale. The samples were judged on appearance, odor, flavor, and texture by 12 experienced taste panelists composed of staff members of the laboratory. To avoid sensory fatigue, seldom were more than 4 samples served at a time. The shrimp were cooked by steaming 10 minutes and were served hot for evaluation. Panelists judged samples in individual booths and arrived at their scores independently of one another.

The bacteriological analysis of experimental shrimp consisted of total

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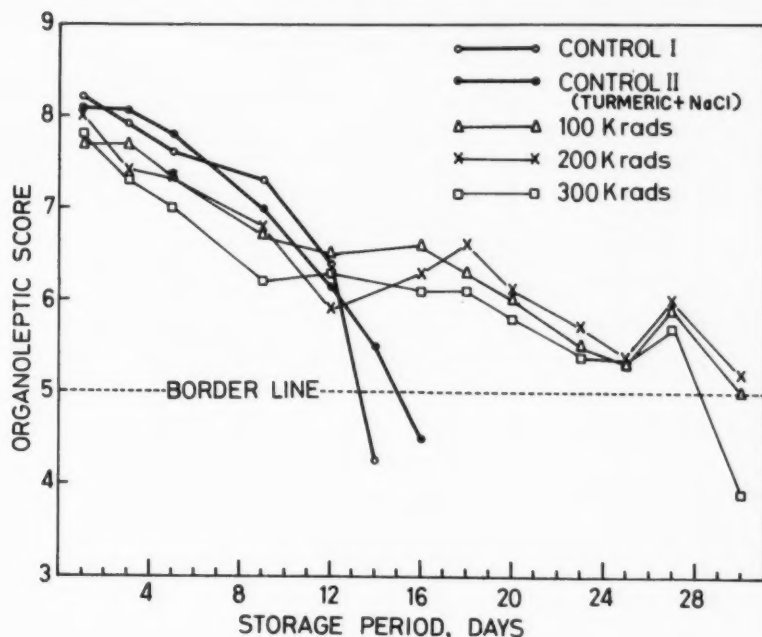


Figure 1.—Overall organoleptic score of control and irradiated shrimp based on hedonic scale with 9 as "like extremely," 1 as "dislike extremely," and 5 as "neither like nor dislike" (on the borderline of acceptability).

aerobic plate counts performed on samples of randomly chosen shrimp of the appropriate sample groups.

Aerobic total bacterial counts were obtained by pour plate techniques using nutrient agar enriched with 0.5 percent yeast extract, coliform groups by using lactose broth, and proteolytic activity by gelatin liquefaction tests on nutrient agar-gelatin media flooded with a solution of 2N HCl containing 15 percent Hg Cl₂.

RESULTS AND DISCUSSION

The storage life of samples held at 33°F when judged by experienced taste panelists (see Fig. 1) was as follows: control 13 days, control (treated) 15 days, and all irradiated samples were acceptable up to 28 days. The irradiated samples scored 0.5 to 1.0 point less on the hedonic scale than the controls during early storage. Shrimp irradiated at the 300 kilorad level exhibited greater irradiation off-flavor than 100 and 200 kilorad level irradiated samples, but the difference decreased on subsequent storage (Scholz 1962). The 300 kilorad level samples did not have a longer storage life than those of the 100 and 200 kilorad levels but scored lower and were completely rejected by the 30th day.

The gradual decrease in acceptability of irradiated samples during the first 9-12 days of storage does not correlate with bacterial growth. Figure 2 shows that there is no increase in total bacterial plate count during this period for all the irradiated samples. The decrease in acceptability during this period might be related to changes in chemical constituents affected by endogenous enzymes or bacterial enzymes produced earlier.

It is evident from the work of Ron-sivalli et al. (1965) and Kaylor et al. (1970) that the application of 300 kilorads of ionizing radiation reduces the total bacterial plate count up to 3 log cycles. In this particular experiment the bacterial loads of control samples increased by 3 log cycles at the end of the

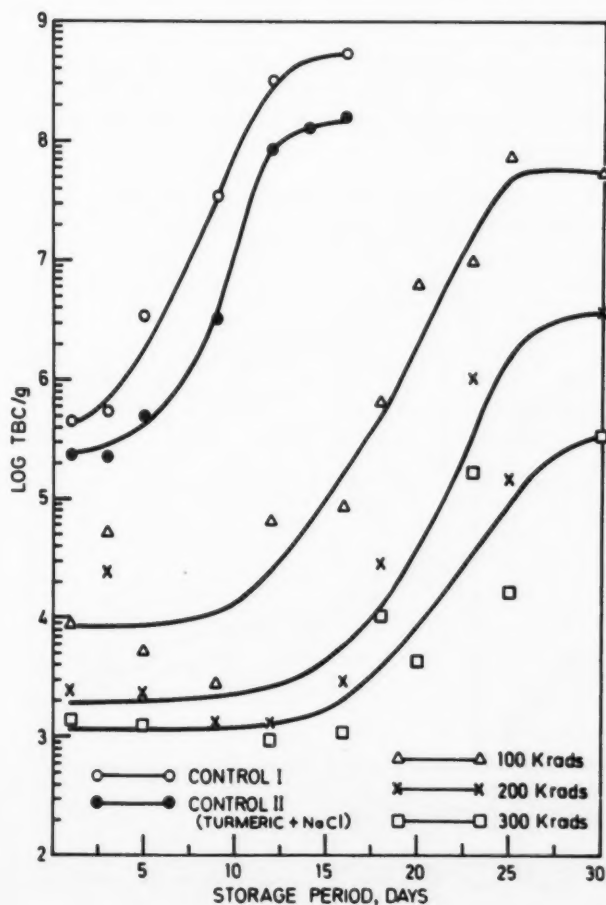


Figure 2.—Bacterial load of control and irradiated shrimp.

storage life. The irradiated samples, however, showed a one log cycle reduction for each additional 100 kilorads of ionizing radiation.

In the case of control samples, there was scarcely any bacterial lag phase. The log phase was steep, leading to less shelf life, whereas in the case of irradiated samples, the lag as well as the log phase was extended. This may be due to a combination of effects: shift in microflora surviving the irradiation treatment (MacLean and Welander 1960), damage inflicted on the bacterial cell (Stapleton 1955), and the retarding effect that irradiated substrates and packaging have on microbiological growth (Solberg and Nickerson 1963). Although the time required for bacterial surviving irradiation to return to their original level increased with dose, the samples at all dose levels spoiled at the same time. This may be due to survival of different microflora at different doses which eventually cause spoilage. Another explanation might be that the spoilage rate is dependent continually on temperature, but dependent on bacteria only until the available enzymes have increased to reach a maximum level of activity on the substrate (Charm et al. 1972).

Table 1.—Spoilage characteristics at the end of storage life of nonirradiated, irradiated, and pretreated plus irradiated shrimp held at 33°F.

Sample	Storage time (days)	Comments of panel	
		Raw	Cooked
Control (raw)	13	Melanosis, odor of decomposition	Melanosis, ammonia odor, inedible
Control	15	Some melanosis, spicy odor and odor of decomposition	Some melanosis, ammonia odor, spicy odor
turmeric-salt treated ¹	28	Melanosis, odor of decomposition	Melanosis, ammonia odor, decomposed
100 kilorads	30	Melanosis, slight irradiation odor, fishy odor	Melanosis, slight irradiation flavor, ammonia odor, stale
200 kilorads	30	Melanosis, some irradiation odor, odor of decomposition	Melanosis, irradiation flavor, ammonia odor, inedible
300 kilorads	40	No melanosis, spicy odor, slight incipient spoilage odor	Saffron color, spicy flavor, slight ammonia odor
Pretreatment + 100 kilorads ¹	42	No melanosis, no irradiation odor, spicy odor predominant	Saffron color, spicy flavor, no irradiation flavor
Pretreatment + 200 kilorads ¹	42	No melanosis, no irradiation odor, slight ammonia odor, spicy odor	Saffron color, spicy flavor, no irradiation flavor, slightly sweetish
Pretreatment + 300 kilorads ¹			

¹Pretreatment dip with turmeric spice either alone or in combination with sodium chloride at 5% level each for 15 and 30 minutes followed by irradiation at 100, 200, and 300 kilorads.

Control (raw as well as treated) and irradiated shrimp developed black spots typical of shrimp (melanosis) and developed off-odor and off-flavor at the highest dose level. It will be seen from Table 1 that pretreatment with 5 percent turmeric and 5 percent salt dip for 15 and 30 minutes followed by irradiation

at the three dose levels resulted in a lack of melanosis and a lack of off-odor and off-flavor. When cooked, the pretreated samples developed a somewhat saffron color which enhanced their appearance.

Shrimp treated with turmeric and salt and irradiated at different dose levels exhibited a shelf life of 42 days (Fig. 3)

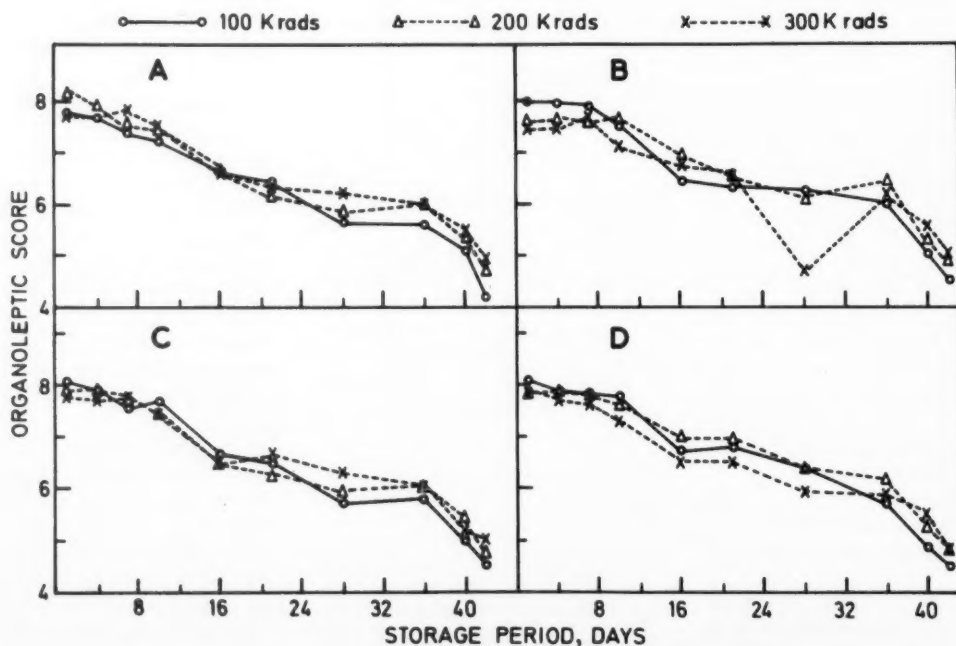


Figure 3.—Overall organoleptic score of combination-treated shrimp based on hedonic scale. A = 5% turmeric predip for 15 minutes. B = 5% turmeric predip for 30 minutes. C = 5% turmeric + 5% NaCl predip for 15 minutes. D = 5% turmeric + 5% NaCl predip for 30 minutes.

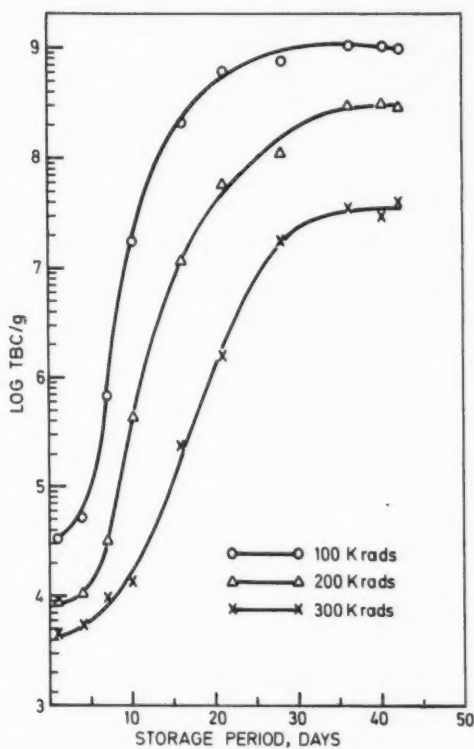


Figure 4.—Bacterial load of 5% turmeric predip for 15 minutes and irradiated (combination-treated) shrimp.

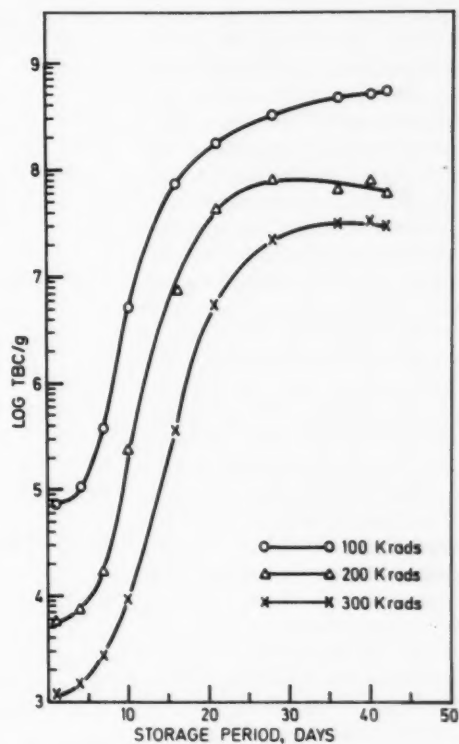


Figure 5.—Bacterial load of 5% turmeric predip for 30 minutes and irradiated.

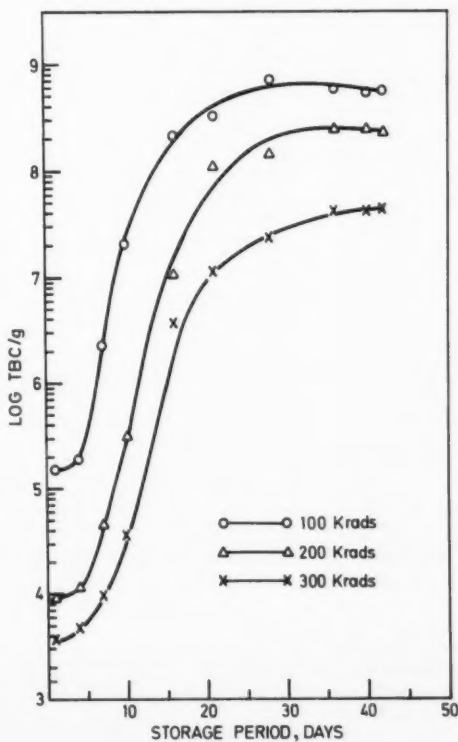


Figure 6.—Bacterial load of 5% turmeric + NaCl predip for 15 minutes and irradiated.

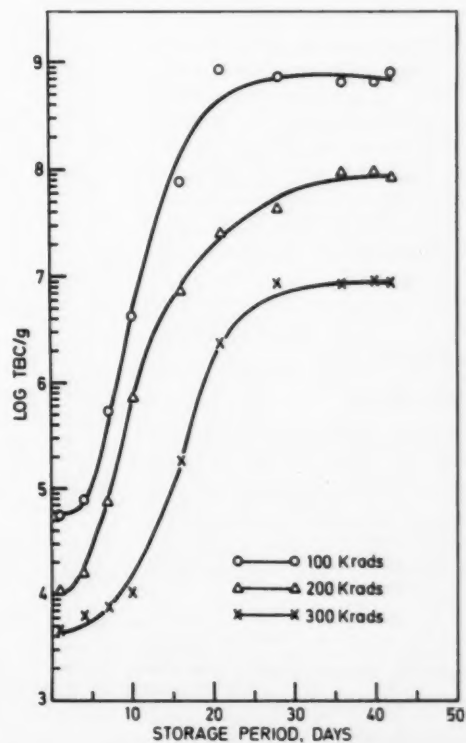


Figure 7.—Bacterial load of 5% turmeric + 5% NaCl predip for 30 minutes and irradiated.

as against 30 days for irradiated shrimp without spice and salt. The difference in storage life of the two control samples is not noteworthy when compared with the difference in the irradiated samples and those receiving the pretreatment plus irradiation. This indicates a complementary effect of the turmeric/salt/radiation combination. The different pretreatments also indicate that salt alone fails to have any contributory effect upon either the extension in storage life or in ameliorating off-odor and off-flavor of the irradiated shrimp. It is also interesting to note that the pretreated and irradiated shrimp consistently scored one-half to one full scale point above irradiated samples without pretreatment. The low point in the 300 kilorad curve, Fig. 3B, is believed to be an inexplicable artifact.

Figures 4 to 7 showed high total bacterial count (TBC) of combination-treated shrimp when compared with control and irradiated samples (Fig. 2) by a factor of 10 to 100 times at the end of their storage lives. Similar observations have been made by other workers (Spinelli et al. 1965, Adams et al. 1964, Kumta et al. 1970). Unlike the irradiated samples, the combination-treated shrimp did not exhibit a bacterial lag phase; the log phase curve is steeper and the count at the end of storage life was 10^9 /g. The proteolytic activity of bacteria expressed as percent of TPC did not correlate with organoleptic score. Coliforms were absent in all samples. This is confirmed by Kaylor et al. (1970) in his work with the parent stock of shrimp from which these samples were derived.

Table 2 summarizes the storage life of control, irradiated, and combination-treated shrimp.

CONCLUSION

It would appear that turmeric in combination with low-dose ionizing radiation exerts a complementary effect in extending the shelf life of shrimp and imparts desirable attributes of flavor and appearance. While all levels of ir-

Table 2.—Storage life, in days at dose levels, of control, irradiated, and combination-treated shrimp.

	Description	Kilorads			
		0	100	200	300
I	Control	13			
II	Control turmeric + sodium chloride treated	15			
III	Irradiated samples		28	30	30
IV	5% turmeric dip for 15 minutes + irradiated		40	42	42
V	5% turmeric dip for 30 minutes + irradiated		40	42	42
VI	5% turmeric + 5% NaCl dip for 15 minutes + irradiated		40	42	42
VII	5% turmeric + 5% NaCl dip for 30 minutes + irradiated		40	42	42

radiation studied were effective, the 15-minute turmeric dip and 200 kilorad dose level produced an adequate storage life for shrimp when held at 33°F.

ACKNOWLEDGMENT

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*Energy constraints may
put distant-water trawl
fleets on a short leash.*

Energy Efficiency Comparison between the Washington and Japanese Otter Trawl Fisheries of the Northeast Pacific

DOUGLAS J. WIVIOTT and STEPHEN B. MATHEWS

It is well known that the large, mothership-based trawlers from foreign nations, principally Japan and the USSR, fishing in the northeastern Pacific Ocean are more efficient than the smaller U.S. trawlers operating in parts of the same waters in terms of traditional units of efficiency, such as pounds landed per trawling hour.

In fact, much concern has been expressed not only by the west coast U.S. fishery industry but elsewhere in the world—that fleets of large, distant-water trawlers will outcompete and therefore displace fleets of smaller, home-based fishing vessels because of their greater efficiency.

To compare these two so different types of fishing operations we undertook an analysis of the Washington State and the Japanese otter trawl fisheries of the northeast Pacific, taking as our principal parameter for comparison the ratio of outputs of edible fishery products to inputs of manpower, materials, and fuel (all converted to energy equivalents):

$$\text{Efficiency} = \frac{\text{kcal food output}}{\text{kcal input}}$$

Energy output:input analysis is receiving increasing attention in studies of agricultural systems (Pimentel et al., 1973 and Steinhart and Steinhart, 1974) and a great many other industries (Herendeen, 1973) as global concerns

for decreasing supplies of nonrenewable fuels intensify.

THE FISHERIES

The Washington trawl fishery, which is about 60 years old, is presently composed of 81 (1971-72 average) licensed vessels, of which about 30 operate as full-time trawlers which fish the waters of the continental shelf from the Columbia River mouth to northern British Columbia. The average trawler in this fleet is 80 feet in length and weighs 86 gross tons. Hulls are generally of steel (wood in older boats) and the engine is typically a 300-hp diesel. The length of stay on the fishing grounds varies from single-day trips to a maximum of about 14 days. Other than separating and icing the catch, no processing is done aboard. The data for the present analysis are from 11 full-time trawlers which operated during 1971 and 1972 and for which annual fuel consumption and landing figures were available.

The segment of the Japanese trawl fishery selected for comparison consisted of 32 mothership-based stern trawlers which operated along the continental shelf region of the Gulf of Alaska in 1972¹. Commercial Japanese trawling in this area of the northeast Pacific began in 1965. Typically these vessels are on the grounds for several months at a time, unloading their catches periodically to the motherships wherein processing takes place. The geographical center of operation of the Japanese vessels is north of that of the

Washington fleet, but there is overlap in fishing grounds between the two. The Japanese trawlers ranged in size from 345 to 5,460 gross tons, with an average of 1,947. Hulls are of steel and the diesel engines used range in power from 850 to 5,700 hp.

Table 1 compares the physical specifications for vessels in the two fleets. The average fuel consumption figures need further discussion. For the Washington fleet, they are based on specific consumption figures for 11 vessels furnished by the fuel supplier. For the Japanese fleet, no such reliable figures were available. Thus, we had to rely on estimates of fuel consumption for vessels in their general horsepower range (Table 2). The average fuel consumption (Japanese vessel) from four separate estimates was 1.49 gal per horsepower-day with an average of 2,648 horsepower per vessel and 205 operating days per year per vessel; we estimated the annual fuel consumption per vessel to be 808,832 gal. The assumed 205 fishing days used for the Japanese trawlers, which is the same as Washington trawlers, is probably minimal because of the additional running time of the Japanese vessels to and from the fishing grounds.

The total catches for both fisheries are listed by species in Table 3. Pacific ocean perch make up the bulk of the Japanese catch, with pollock and black

Table 1.—Average specifications for 11 Washington and 32 Japanese otter trawlers operating in the Northeast Pacific, 1971-1972.

	Washington trawlers	Japanese trawlers
Vessel length	80 ft ¹	Not available
Hull material	steel	steel
Gross tonnage	'86	'1,947
Type of vessel	stern trawl	stern trawl
Horsepower of engine	'300	'2,648
Crew size	4 men ¹	67 men ²
Annual days		
away from port	205	205
Trawl head rope length	82 ft ¹	163 ft ²
Trawl ground rope length		
length	96 ft ¹	226 ft ²
Mesh size—cod end	3.5 inches ¹	3.6 inches ²
Annual landings		
round weight	990,831 lb per vessel ³	5,378,189 lb per vessel ⁴
Annual diesel fuel consumption ⁵	27,107 gal per vessel	808,832 gal per vessel

¹Pattie, B. and G. DiDonato. Washington Department of Fisheries, Seattle, Wash. Pers. Commun.

²International North Pacific Fisheries Commission, unpublished documents and records supplied by K. Mura, Research and Development Dept., Fishery Agency of Japan, Tokyo.

³Ward, D. Washington Department of Fisheries, Olympia, Wash. Pers. Commun.

⁴Average pounds landed per Japanese vessel is catch by total fleet (Table 3) divided by 32 (number of vessels).

⁵Fuel consumption figures are discussed in text and Table 2.

¹There were 42 vessels licensed to fish these waters in 1971 and 1972, but only 32 actually fished.

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Table 2.—Estimated diesel fuel consumption by Japanese trawlers.

Gallons per horsepower-day	Source and method of computation
1.41	According to Henry Shek, marine engineer with NOAA (Seattle, Wash.), a vessel in the horsepower range of the Japanese trawlers consumes about 0.425-lb fuel per horsepower hour. Diesel fuel weighs about 7.24 lb per gallon and a continuous 24 hours per day operation was assumed.
1.55	Robert French, in charge of the U.S. National Marine Fisheries Service, NOAA foreign trawl observer program, (Seattle, Wash.) reported that one of his technicians aboard a 5,900-ton Japanese trawler in the Bering Sea observed a daily fuel usage of 30 metric tons.
1.21	Labberton and Marks (1945) reported that an efficient, 4,000 hp diesel vessel consumed fuel at a rate equivalent to 4,840 gal per 24-hour day.
1.80	A representative of a Seattle-based marine fuel distributor estimated that U.S. king crab vessels of about 1,000 hp (the largest U.S. commercial fishing vessels operating in the northeastern Pacific) consume 70-80 gal of diesel fuel per hour, or about 1,800 gal per 24-hour day of continuous operation.
Mean 1.49	

Table 3.—Annual catches in pounds round weight by the Washington and Japanese otter trawl fisheries in the north Pacific, 1971-1972 average.

Species	Washington fishery	Japanese fishery
Green sturgeon	13,726	—
Butter sole	1,610	—
Dover sole	1,284,093	—
English sole	2,056,306	—
Petrale sole	1,419,681	—
Rex sole	79,629	—
Rock sole	561,587	—
Sand sole	174,012	—
Sanddab	70	—
Starry flounder	638,201	—
Turbot	36,877	—
Black cod	103,990	14,033,000
Lingcod	1,732,733	—
Pacific cod	7,479,742	1,317,000
Pollock	70,376	23,760,000
Hake	7,375,238	1,992,000
Rockfish	10,603,415	4,497,000
Pacific ocean perch	8,398,557	109,378,000
Blue sea perch	251	—
White sea perch	3,668	—
Ratfish	33,854	—
Dogfish	31,380	—
Skate	15,141	—
Octopus	22,072	—
Squid	2,243	—
Shad	245	—
Mackerel	21	—
Miscellaneous	523,144	17,125,000
Total	42,661,882	172,102,000

Sources: Washington catches are from the Washington Department of Fisheries annual catch statistics, unpublished but available in bound volumes in Olympia, Wash., and furnished by Dale Ward of that Department. Japanese catches are from unpublished records of the International North Pacific Fishery Commission, obtained from their central office in Vancouver, B.C.

cod, species not especially sought by the Washington trawlers, making up important segments of the catch. The Washington catch is more diversified, but the principal fish are Pacific ocean perch, rockfish of several species, Pacific cod, and soles and flounders of several species.

ENERGY INPUTS

The principal energy inputs are diesel fuel, manpower, and materials for vessel construction. Conversion of annual fuel and manpower inputs to kilogram-calories was relatively straightforward; a working man requires approximately 3,110 kcal per

Table 4.—Energy requirements to build a steel-hulled fishing vessel of approximately 200 gross tons.

Item of input	Kcal
5,000 8-hr man days @ 3,110 kcal/day	15,550,000
100,000 kw-hr electrical power @ 860 kcal/kw-hr	86,000,000
230 tons steel @ 1.7×10^7 kcal/ton	3,910,000,000
35,000 ft ³ natural gas @ 260 kcal/ft ³	9,100,000
114,192 ft ³ oxygen @ 260 kcal/ft ³	29,690,000
29,250 ft ³ acetylene @ 260 kcal/ft ³	7,605,000
Total	4,057,945,000
Input per gross ton	$20,289 \times 10^6$

Sources: Items of input, personal communication with Puget Sound shipbuilding firm; conversion factor kw-hr to kcal (Labberton, 1945); conversion factors steel, natural gas, oxygen, and acetylene (Steinhart and Steinhart, 1974).

Table 5.—Annual energy inputs for Washington and Japanese trawlers operating in the northeastern Pacific.

	Washington trawler	Japanese trawler
Fuel energy (34,650 kcal/gal × gal/yr)	939 × 10 ⁶ kcal	28,026 × 10 ⁶ kcal
Manpower energy (3,110 kcal/man day × crew size × 205 days)	3×10^6	43×10^6
Vessel construction (1.014 × 10 ⁶ kcal/gross ton/year × average gross tons)	87×10^6	1,974 × 10 ⁶
Total energy	$1,029 \times 10^6$ kcal	$30,043 \times 10^6$ kcal

day (Pimentel, et al., 1973). A gallon of diesel fuel contains 34,650 kcal of energy (Hougen, et al., 1959). Additional energy required to refine diesel fuel from petroleum is only a small fraction of the amount contained in the product (less than one-fortieth (Stanford Research Institute, 1972)); so this was ignored. The estimate of energy requirements in vessel construction was derived from information fur-

nished by a Puget Sound boat yard on the inputs required to build a 200-gross ton, steel-hulled fishing vessel (Table 4)². For this vessel, $20,289 \times 10^6$ kcal per gross ton were required. We estimated the fishable life of a steel-hulled vessel to be 20 years; consequently, the annual energy input per year per gross

²We are indebted to Lee Morgan, College of Fisheries, University of Washington, Seattle, who computed this information from the boat yard records, and to the boat yard naval architect, who made the records available.



Washington State trawler.

ton of vessel was estimated to be one-twentieth the total input value, or 1.014×10^6 kcal.

The annual energy inputs per vessel are computed in Table 5. An average Washington trawler requires $1,029 \times 10^6$ kcal per year. A Japanese trawler requires $30,043 \times 10^6$ kcal per year. The principal item of energy input is fuel, representing over 90 percent of the total energy requirements for both fleets.

ENERGY OUTPUTS

Pounds of fish were converted to kilogram-calories of consumable food by the percent of total round weight that is edible for each species and the percentages of the edible portions that are fat and protein (Table 6), and the conversion factors of protein and fat weight to kilogram-calories (1 gram protein = 4.2 kcal and 1 gram fat = 9.5 kcal) (Borgstrom, 1968). Computed on this species by species basis, the annual output in terms of food energy in the edible flesh is $8,180 \times 10^6$ kcal for the Washington fishery and $39,808 \times 10^6$ kcal for the Japanese fishery. Based upon the poundages in Table 3, the energy equivalents per pound of round weight landed are:

Washington fleet - 171 kcal/lb

Japanese fleet - 231 kcal/lb.

EFFICIENCY

Energy output:input ratios per trawler for the 11 Washington and 32 Japanese trawlers were as follows:

Trawler	Round weight landed (lb)	kcal per lb	Energy value of landings (kcal)	Energy inputs (kcal)	Efficiency outputs/inputs (percent)
Washington	990,831	171	169×10^6	$1,029 \times 10^6$	16
Japanese	5,378,186	231	$1,242 \times 10^6$	$30,043 \times 10^6$	4

Thus, the Washington fleet is several times more efficient than the Japanese fleet in these terms. The primary reason is the comparative fuel consumption. A Japanese trawler lands about five times as many pounds of fish per year as a Washington trawler, but its fuel consumption may be over 30 times as high.

Put into these simpler terms for comparison we see:

Species	Percent edible flesh		
	round weight	protein	fat
Green sturgeon	50.0	16.0	10.0
(<i>Acipenser medirostris</i>)			
Butter sole	49.3	17.1	1.1
(<i>Isopsetta isolepis</i>)			
Dover sole	47.9	15.2	0.8
(<i>Microstomus pacificus</i>)			
English sole	60.2	17.0	1.6
(<i>Parophrys vetulus</i>)			
Petrale sole	62.9	18.2	1.5
(<i>Eopsetta jordani</i>)			
Rex sole	49.4	16.6	0.7
(<i>Glyptocephalus zachirus</i>)			
Rock sole	47.7	18.3	0.7
(<i>Lepidopsetta bilineata</i>)			
Sand sole	61.0	17.2	0.5
(<i>Psettichthys melanostictus</i>)			
Sanddab	60.2	17.0	1.6
(<i>Citharichthys sordidus</i>)			
Flounder	47.9	17.1	1.1
(<i>Platichthys stellatus</i>)			
Turbot	59.1	17.9	2.4
(<i>Atheresthes stomias</i>)			
Miscellaneous	49.8	18.0	1.1
Black cod	62.8	12.9	15.2
(<i>Anoplopoma fimbria</i>)			
Lingcod	47.0	17.7	1.0
(<i>Ophiodon elongatus</i>)			
Pacific cod	37.8	17.9	0.6
(<i>Gadus macrocephalus</i>)			
Pollock	35.0	16.0	2.0
(<i>Theragra chalcogramma</i>)			
Hake	49.0	16.1	2.5
(<i>Merluccius productus</i>)			
Rockfish	46.5	19.0	1.5
(<i>Sebastes</i> sp.)			
Pacific ocean perch	50.2	19.2	1.5
(<i>Sebastes alutus</i>)			
Blue perch	40.0	17.5	2.0
(<i>Embiotoca jacksoni</i>)			
White seaperch	40.0	17.5	2.0
(<i>Phanerodon furcatus</i>)			
Rattfish	36.9	14.0	10.0
(<i>Hydrolycus collieri</i>)			
Dogfish	36.9	15.0	13.0
(<i>Squalus acanthias</i>)			
Skate	50.0	16.0	6.0
(<i>Rajidae</i>)			
Octopus	59.0	19.0	0.8
(<i>Polypus hongkongensis</i>)			
Squid	59.8	19.3	0.7
(<i>Loligo opalescens</i>)			
Shad	60.0	18.7	9.8
(<i>Alosa sapidissima</i>)			
Mackerel	45.0	19.0	11.0
(<i>Scombridae</i>)			

¹All yields are based on what could be obtained from whole fish using flesh separating machine (Miyachi and Steinberg, 1970).

Sources: Values obtained by considering data from a wide variety of sources: (Miyachi and Steinberg, 1970; Thurston, 1961a, 1961b, and 1961c; Patashnik et al., 1970; and Dan Sortwell, John Dassow, and Richard Nelson, Pacific Fishery Products Technology Center, National Marine Fisheries Service, NOAA, Seattle, pers. commun.)

Washington trawler again appears much more efficient.

DISCUSSION

On an output:input basis the Washington fleet of small, short-trip vessels appears to be more efficient than the Japanese mothership-based fleet of large stern trawlers. The greater amount of fuel per unit of fish caught is the primary reason for the difference. Our figures for fuel consumed by the Washington fleet, we feel, are quite accurate, being based upon annual consumption of 11 vessels. Estimated fuel

	Pounds of fish landed/ gal of fuel
Washington trawl fleet	36.55 lb/gal
Japanese trawl fleet	6.65 lb/gal

Other measures of efficiency can, of course, be calculated from the data presented such as pounds of fish per man day, or pounds of fish per gross ton of vessel. For such comparisons, a



Japanese stern trawler.

consumption for the Japanese vessels is less likely to be accurate since we did not have vessel by vessel consumption reports. However, even if we have overestimated Japanese fuel consumption by a factor of two or even three, our basic conclusion that the Washington fleet is more efficient is still valid. It should be pointed out that the Japanese do process some of their catch at sea, which is another energy factor that should be considered. For the scope of this study though, processing energy is not evaluated for comparison.

What are the implications of the foregoing analysis? At the present time

the costs of fuel and manpower in the two countries relative to the prices obtainable for fish products must be such that each type of operation is profitable in its respective nation, since both countries operate under a capitalistic system where monetary outputs must exceed monetary inputs in order for industries to survive. Thus, cost efficiency as yet guides the kind of fishery and other enterprises that are carried forth, not energy efficiency. However, if conventional fuels become increasingly costly relative to other resources on world markets and if costs of manpower and resources tend to

equalize amongst nations, free enterprise constraints may themselves tend to favor the local, small boat, more energy efficient, fishery operations over the distant water fleets of larger trawlers. Thus, even without some future scheme of global allocation of fuels to their most efficient use, one implication of the foregoing analysis is that distant-water trawl fleets may very well be dinosaurs.

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*With proper equipment
and knowledge, the spiny
lobster fishery off Florida
can be quite profitable.*

Costs and Earnings in the Spiny Lobster Fishery, Florida Keys

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gross tons in the early 1950's to about 30 gross tons in the latest years. As still another indication of increased fishing activity, the average number of traps rose from 80 to 440 per fishing craft.

In 1973, about 20 percent of landings on Florida's west coast came from lobstering in distant waters in the Caribbean off the coasts of Nicaragua and Honduras. The distant water fleet operates mainly out of the St. Peters-

INTRODUCTION

The spiny lobster (*Panulirus argus*) occupies a prominent place on the list of highest valued seafood items accepted by the U.S. consumer. In terms of unit value to the fishermen, it is surpassed only by the scallops (meat), the American lobster, some clams, and some shrimps¹. The great majority of spiny lobsters caught by U.S. fishermen are landed in Florida ports. In 1973, out of 11.1 million pounds of total Florida landings, valued at \$11.6 million, 45 percent by weight (46 percent by value) were landed on Florida's west coast with the remainder occurring on the east coast².

Florida's west coast fishery for spiny lobster has been growing rapidly over the past 25 years. The number of vessels and boats (vessels have a capacity of 5 net tons or more, boats a capacity of less) registered for this fishery increased from 71 in 1950 to 337 in 1971, with the number of traps going from 5,715 to 147,037 during that period (Table 1). The value of landings rose from around \$200,000 a year in the early 1950's to over \$5 million in the early 1970's. A fivefold increase both in landings and in price at dockside brought about this rise in value (Fig. 1).

Parallel to the changes in number, the size of the average vessel in this fishery also increased from about 10

Table 1.—Florida west coast spiny lobster fishery: Number of vessels, boats, pots, and fishermen; years 1950-1971.

Year	Number of vessels ¹	Vessels' total gross tonnage	Number of boats ²	Number of fishermen On vessels	On boats	Number of Traps
1950	2	17	69	4	90	5,715
1955	2	20	61	4	61	12,700
1960	16	171	152	29	192	54,640
1965	28	308	188	56	306	89,700
1966	58	824	210	104	300	74,550
1967	75	1,189	224	143	330	91,800
1968	137	3,433	135	323	214	98,500
1969	92	2,185	176	184	255	96,955
1970	123	3,534	214	287	331	150,050
1971	142	4,184	195	364	259	147,037

¹Vessel: A commercial fishing craft having a capacity of 5 net tons or more.

²Boat: A commercial fishing craft having a capacity of less than 5 net tons.

Source: Fishery Statistics of the United States, various years. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (former Bureau of Commercial Fisheries), Washington, D.C.

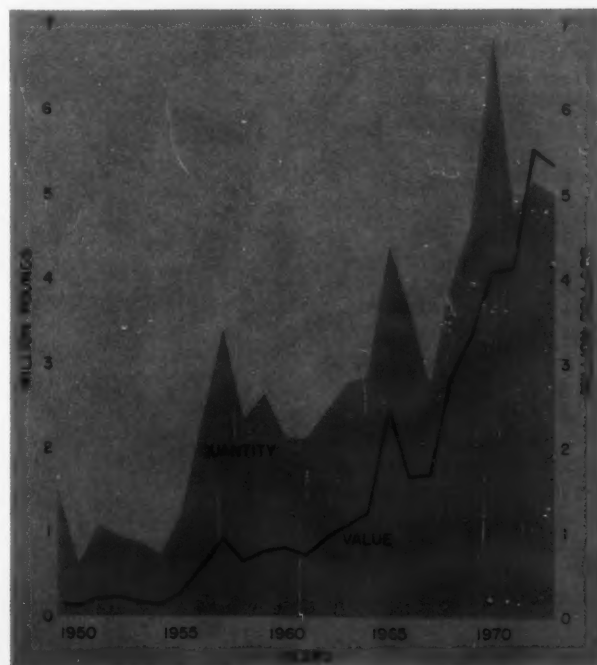


Figure 1.—Florida west coast: Spiny lobster landings, years 1949-1973.

¹Fisheries of the United States, 1973, Current Fishery Statistics No. 6400, Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Washington, D. C., March 1974.

²For statistical purposes, the county line between Dade and Monroe counties in southern Florida is used as the dividing line for Florida's east coast and west coast landings.

*With proper equipment
and knowledge, the spiny
lobster fishery off Florida
can be quite profitable.*

Costs and Earnings in the Spiny Lobster Fishery, Florida Keys

BRUNO G. NOETZEL and MIKOLAJ G. WOJNOWSKI

INTRODUCTION

The spiny lobster (*Pandalus argus*) occupies a prominent place on the list of highest valued seafood items accepted by the U.S. consumer. In terms of unit value to the fishermen, it is surpassed only by the scallops (meat), the American lobster, some clams, and some shrimps¹. The great majority of spiny lobsters caught by U.S. fishermen are landed in Florida ports. In 1973, out of 11.1 million pounds of total Florida landings, valued at \$11.6 million, 45 percent by weight (46 percent by value) were landed on Florida's west coast with the remainder occurring on the east coast².

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gross tons in the early 1950's to about 30 gross tons in the latest years. As still another indication of increased fishing activity, the average number of traps rose from 80 to 440 per fishing craft.

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Table 1.—Florida west coast spiny lobster fishery. Number of vessels, boats, pots, and fishermen, years 1950-1971.

Year	Number of vessels	Vessels, total (gross tonnage)	Number of boats	Number of fishermen (on vessels, on boats)	Number of traps
1950	71	678	108	4	5,715
1955	92	720	147	4	72,700
1960	146	1,573	620	24	141,640
1965	238	3,008	1,938	96	209,700
1966	298	3,224	2,770	104	241,800
1967	375	3,769	2,234	143	311,800
1968	437	4,433	2,471	127	361,500
1969	482	4,760	2,791	164	461,000
1970	713	6,904	3,114	207	750,000
1971	942	11,564	3,995	294	1,470,037

¹Vessel: A commercial fishing craft having a capacity of 5 net tons or more.

²Boat: A commercial fishing craft having a capacity of less than 5 net tons.

Source: Fishery Statistics of the United States, various years. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Bureau of Research, Commercial Fisheries, Washington, D.C.

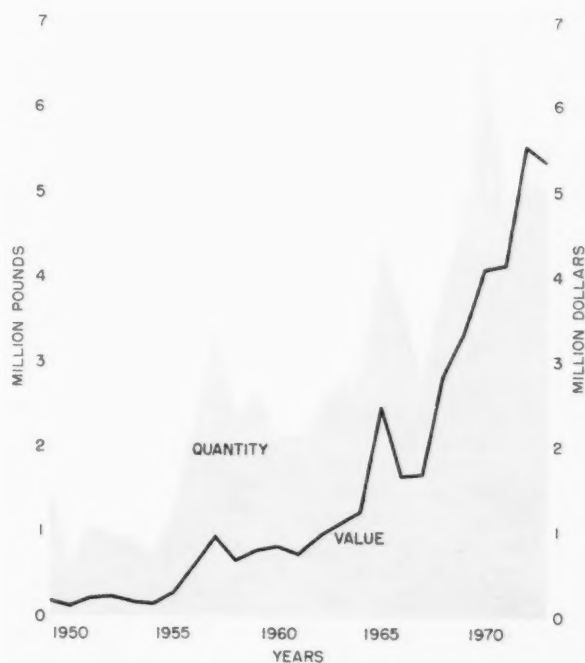


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Florida lobster traps with floats.

Splitting lobster tails prior to packaging for restaurant use.

burg-Tampa area. According to Holmsen (1972), vessels in this fleet are 50 to 80 feet in length and fish about 400 traps. The trip length is 60 to 90 days and the catch is landed in the form of frozen tails.

The remaining 80 percent of landings originated in local waters along the Florida Keys. Vessels and boats in this local fishery are based mainly in Key West and Marathon, and are, in general, smaller than vessels in the distant water fishery. It is this fleet of small vessels and boats that is the subject of the present analysis.

THE FISHERY

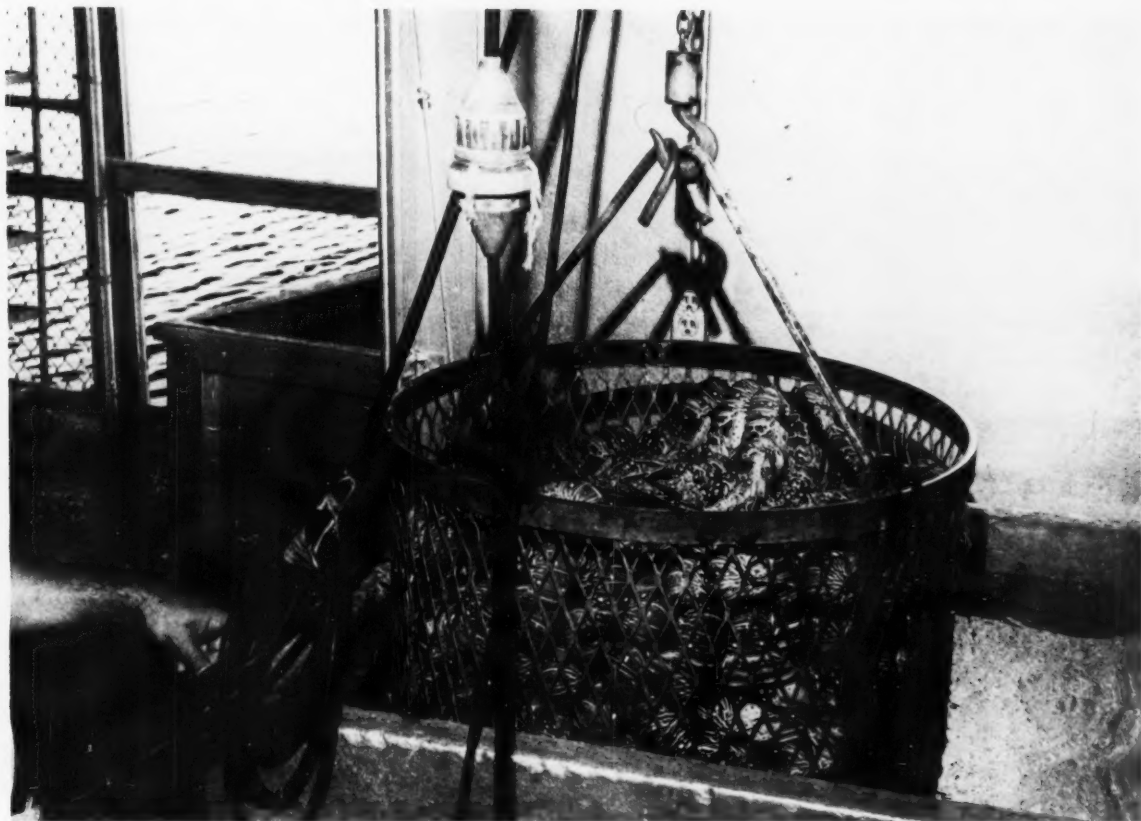
Laws and Regulations

By State law, a license is required of all boats and vessels (and other craft) equipped to take saltwater products from the tide or salt waters of the State. A certificate of registration is issued with each license sold. The fishing season for spiny lobster is closed between 31 March and 1 August of each year. Traps may be placed in the water 10 days prior to the opening of the season, and must be removed within 5 days after closure. Traps that may be used are of wood slat, in size not to exceed $3 \times 3 \times 2$ feet, or the equivalent in cubic feet. Each trap has a buoy attached to it except where the traps are tied together

in trotlines of not more than 20 traps. These trotlines have a flag buoy attached to each of the end traps. Buoys and traps must bear a trap permit number permanently attached to the device.

As to minimum size restrictions in this fishery, the spiny lobsters allowed to be taken must have a carapace measurement of more than 3 inches or a tail measurement of more than $5\frac{1}{2}$ inches, not including any protruding muscle tissue. Lobsters must remain in whole condition at all times while being transferred on, above, or below the waters of the State and the practice of separating the tail from the carapace section is prohibited except by special permit issued by the Director of the Board of Conservation. Egg-bearing female lobsters shall not be taken or possessed at any time, and when found





Rinsing lobster prior to cooking.

in traps they must be immediately returned to the water free, alive, and unharmed. The practice of stripping egg-bearing lobsters in order to remove the eggs is prohibited.

Fishing Operations

Fishing grounds are located along the reefs on both sides of the Florida Keys, approximately 3-6 miles from port. Spiny lobsters are usually caught in less than 30 feet of water, but they exist in much greater depths where there is a rocky bottom (Smith 1958). The 1-day trips consist of returning in the early morning to the area where the fisherman's traps were placed in water before; working the traps, i.e., hauling, removing the catch, repairing the traps if necessary, brushing them clean of fouling organisms, rebaiting, and placing them back in water in their approximate original location; and returning to port in the late afternoon for unloading.

The number of traps that can be handled depends on the size of the

crew (one or two men), their skills, and on the location of the trap hauler. With one man on board and the hauler located aft of the boat, up to 120 traps can be handled. With two men on board and the same winch location, the number of handled traps will increase to 200-225. With the winch mounted at the side of the boat, from where the operator has also control of the boat, the number of handled traps increases to 150 and 250, respectively. Fish heads (grouper), canned sardines, or pieces of cow hide are used as bait. The catch is stored in wet burlap bags³.

Some of the vessels and boats are equipped (in addition to lobster traps) with lines and hooks for finfish (grouper, snapper), or with stone crab pots. These are then able to switch to other fishing, mainly towards the end of the season when lobsters are less available, and to extend fishing into the off-season months (April-July).

³Cope (1959) gives a detailed description of gear and fishing methods in this fishery.

THE SAMPLE

Included in our sample for this analysis are 9 vessels and 12 boats, ranging in length from 26 to 40 feet⁴. The average vessel in the sample is 35 feet long, and the average boat 33 feet. The average horsepower of the propulsion engines is 190 hp on the vessels and 120 hp on the boats. Diesel engines, marine gasoline engines, and converted automobile engines are used. The hulls of three of the vessels are made of fiber glass (newer vessels), the remaining vessels and all the boats are of wooden construction. Data on operations of these craft were provided for two full lobster seasons, 1972/73 and 1973/74, with additional data for April-July, 1973 (off season). At least 50 percent of gross revenue produced by each craft during either one of these two seasons is from lobstering. All the vessels and boats are based in Key West and Marathon, Fla.

⁴This size range comprises 70 percent of the vessels and probably all of the 234 boats registered in Monroe County for spiny lobster fishing in 1972.



Typical Florida lobster traps.

REVENUE AND COST STRUCTURE

The average vessel in the sample produced \$19,900 of gross revenue per season (8 months), while the average boat produced \$11,100. In addition, 60 percent of the vessels and 50 percent of the boats had revenues from finfish landings during the four off-season months, which amounted to \$2,100 per vessel and \$1,700 per boat⁵.

⁵State laws prohibit fishing for stone crab between June 1 and October 15 each year.

The distinction made between gross revenue earned by vessels and that earned by boats is based on results obtained from a linear regression analysis⁶. The majority of the vessels have a crew of two, while the majority of the boats carry one man. This fact

⁶In this regression analysis gross revenue figures (dependent variable) were related to the size of a craft and to the number of days fishing (explanatory variables). In addition, a dummy variable was used to indicate a vessel (1) or a boat (0). Both the coefficient of determination for regression (R^2), and the regression coefficient for the dummy variable were found statistically significant at the 1-percent and 5-percent levels, respectively.

primarily explains the higher productivity of vessels (more traps hauled per day).

Other factors which contributed to the variance in gross revenue were:

A. The extent of fishing for species other than lobster during the season⁷. Vessels and boats which had more than 25 percent of their total gross revenue derived from catching stone crab and finfish, were able to produce, *ceteris paribus*, significantly higher revenues during a season than those craft engaged primarily in lobstering (over 75 percent of gross revenue derived from lobster fishing). In addition to the difference in total gross revenue per season there is also a distinctive pattern in the monthly distribution of revenue earned by each of these two groups. Vessels and boats in the latter group have peak earnings in October (about 20 percent of total), with revenues in following months falling rapidly to a low of 4 percent in March (end of season). The other group, with a higher share of other species in landings, displays a more level distribution of revenues, particularly in the last three months of the season (see Fig. 2).

B. The size of the craft expressed in terms of length was found to be a

⁷In a regression analysis, we used dummy variables for various levels of gross revenue from other than lobster fishing (expressed in percent of total gross revenue), together with the same two explanatory variables (size and days fishing).

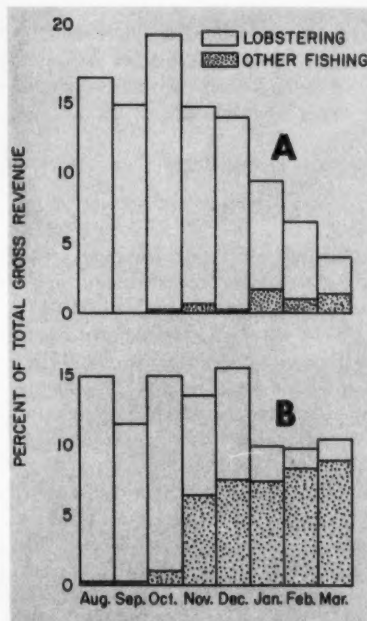


Figure 2.—Sample vessels and boats: Monthly distribution of gross revenue during the season (percent of total).

factor in explaining the variance in gross revenue. As a result, it was decided to split the sample into two size categories: below and over the mean lengths for vessels (35 feet) and boats (33 feet).

Costs of vessel/boat operations were incurred both during the season and during the off-season, even in cases where there was no revenue recorded for the off-season months. In preparation for the season, a considerable cost is incurred for hull and engine repairs. The same applies to purchases or construction of new traps or other fishing gear. Consequently, the cost analysis is based on 12 months of operations with combined revenues, where appropriate. Table 2 presents average revenues from various sources, and average costs of operations per craft per year.

Within the vessel group, costs amount to 54 percent of gross revenue for both small and large vessels. Within the boat group, the subgroup of larger boats with relatively high shares of crab and finfish in landings (last column in Table 2) demonstrates a markedly lower cost ratio (40 percent) as compared to the remaining two subgroups (58 and 61 percent). Those larger boats produced a significantly higher gross revenue in comparison to those in the remaining two subgroups (by 34 and 11 percent, respectively), and at a lower cost (by 7 and 26 percent, respectively).

Traps constitute the highest single cost item. However, the actual cost of traps is higher than that presented here. Figures in Table 2 do not include the cost of the operator's labor in repairing and/or constructing traps. It takes one hour of work to build a new trap from purchased material. A new trap costs about \$9.

Repairs and maintenance is another field of activity where the operator needs to economize on expenses. A great deal of work is done by himself, which is not accounted for in the records.

No share system is in use on these vessels. The most common way of crew remuneration is to pay a lump sum of \$35 to \$45 per trip, depending on the workload, time spent, catch, etc. In general, the crew wage is a low expense item, except for the larger vessels where it amounted to 28 percent of total operating costs.

Table 2.—Spiny lobster vessel and boat operations, Florida Keys: Cost and earnings per craft per year, by size of craft and type of operation.

Size of craft Type of operation ¹	Vessels				Boats			
	less than 35 ft		over 35 ft		less than 33 ft		over 33 ft	
	2	1	1	1	1	2	1	2
(1) Gross revenue:	\$	%	\$	%	\$	%	\$	%
Lobster	6,731	60.7	22,132	91.7	9,956	96.5	10,898	87.9
Crab	72	0.7	16	0.1	130	1.3	434	3.5
Finfish	4,284	38.6	1,996	8.2	228	2.2	1,066	8.6
Total revenue	11,087	100.0	24,144	100.0	10,314	100.0	12,398	100.0
(2) Expenditures:								
Fuel & oil	890		897		519		485	
Bait	104		1,547		504		558	
Groceries	82		309		28		97	
Wages	—		3,675		545		484	
Repairs	1,910		2,113		2,178		1,628	
Traps & other gear	2,711		4,217		2,159		4,168	
Miscellaneous	245		150		58		92	
Total expenditures	5,942	53.6	12,908	53.5	5,991	58.1	7,512	60.6
Gross profit (1 less 2)	5,145	46.4	11,236	46.5	4,323	41.9	4,886	39.4

¹Type of operation: 1—more than 75% of gross revenue earned from lobster landings.

2—less than 75% of gross revenue earned from lobster landings.

Table 3.—Spiny lobster vessel and boat operations, Florida Keys: Calculation of depreciation and interest on investment.

Item	Unit	Vessels		Boats	
		Under 35 ft	Over 35 ft	Under 33 ft	Over 33 ft
(1) Initial cost ¹	dollars	13,000	17,000	9,000	11,000
(2) Useful life-years	number	15	15	15	15
(3) Average age-years	number	21	10	20	18
(4) Allowance for depreciation	dollars	—	1,133	—	—
(5) Average value of craft	dollars	26,000	21,355	24,000	25,000
(6) Value of traps ⁴	dollars	4,500	4,500	3,600	3,600
(7) Total investment (5+6)	dollars	10,500	15,835	7,600	8,600
(8) Interest on investment at 8 percent ⁵	dollars	840	1,267	608	688

¹Estimates based on cost of similar craft in other fisheries.

²Estimated market value based on information from fishermen.

³Average value = initial cost - 0.5 (accumulated depreciation).

⁴500 traps per vessel, and 400 traps per boat at \$9 per trap.

⁵Approximate yield on government bonds.

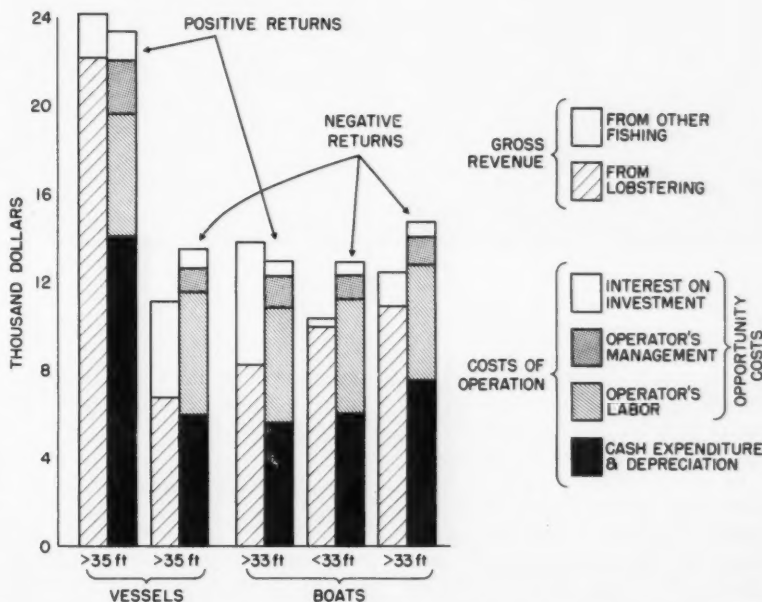


Figure 3.—Return to labor, management, and investment per craft per year.



Lobster being cooked.

Cost of bait is significantly lower on vessels and boats engaged to a greater extent in finfish fishing where part of the catch is used as bait for lobstering.

Prices for lobster and fish are fairly stable over the year. There is no auctioning involved in disposing of the catch. The fishermen accept whatever price is paid at the time by the buying firms. Those firms provide short term financing to the fishermen and keep ac-

counting records for them. Data presented in Table 2 are based on those records.

RETURNS TO CAPITAL AND LABOR

Expenditures in Table 2 represent only part of the costs involved in these fishing operations. The cost of the craft itself in the form of depreciation allow-

ance (fixed costs) has to be accounted for. Also, the implicit costs (or opportunity costs) of capital, and the operator's labor and management have to be added to arrive at the final results of this economic activity.

Table 3 presents estimates of the annual allowance for depreciation, based on available information on the initial cost, useful life, and average age of craft in a given group. Traps are not depreciated in these estimates because the high expenditures in Table 2 (traps and other gear) indicate that this is an annual expense already accounted for⁸. Cope (1959) confirms this assumption stating that most traps must be replaced at the end of a single fishing season. Some other fixed costs, like registration fees and fishing permits, are already accounted for under miscellaneous expenditures in Table 2. No insurance costs were recorded. Except for single cases (new vessels), marine insurance is generally not carried for these craft.

The implicit cost (opportunity cost) of invested capital is the estimated fair return to total investment (craft and traps) in the business, regardless of the actual amount of debt. It is the amount of interest that could be earned by investing this capital in some other business, or in securities. An 8 percent interest rate was assumed for these calculations (see Table 3).

Opportunity cost of labor is the estimated value of the operator's time spent on fishing, repairing his vessel, and building or repairing traps. It indicates what the operator could have earned working in the same capacity for someone else. Available data on fishing effort indicate that an average vessel was out at sea 105 days per season, while a boat was out 95 days. At an average of 10 hours per day, this translates into 1,050 and 950 hours, respectively, of the owner's labor when fishing. In addition to this, it is estimated that the owner of either vessel or boat spent 800 hours per year repairing the craft, repairing or making new traps, or fishing during the off-season months. Thus, at a value of \$3.00 per

⁸On the average there are 500 traps registered per vessel and 400 traps per boat. The purchase price of a trap complete with buoy and rope is about \$9. The cost of material included is about 60-70 percent of this price.

Table 4.—Spiny lobster vessel and boat operations, Florida Keys: Returns to labor, management, and investment, per craft per year.

Size of craft Type of operation*	Vessels		Boats		
	Less than 35 ft	Over 35 ft	Less than 33 ft	Over 33 ft	
	2	1	1	1	2
	Dollars				
(1) Gross revenue	11,087	24,144	10,314	12,398	13,783
(2) Expenditures	5,942	12,908	5,991	7,512	5,566
(3) Depreciation	—	1,133	—	—	—
(4) Charge for interest on investment (8%)	840	1,267	608	688	688
(5) Charge for operator's labor	5,550	5,550	5,250	5,250	5,250
(6) Charge for operator's management	1,109	2,414	1,031	1,240	1,378
Summary					
Return to labor management and investment (1 less 2 and 3)	5,145	10,103	4,323	4,886	8,217
Return to labor and management (1 less 2, 3, and 4)	4,305	8,836	3,715	4,198	7,529
Return to investment (1 less 2, 3, 5, and 6)	-1,514	2,139	-1,958	-1,604	1,589

*Type of operation: 1—more than 75% of gross revenue earned from lobster landings.
2—less than 75% of gross revenue earned from lobster landings.

hour⁹, the total charge for operator's labor is estimated at \$5,550 for a vessel, and \$5,250 for a boat.

Opportunity cost of management is the estimated value of the operator's handling his business (decision-making and risk-taking). It indicates what the operator could have earned managing another similar business. We estimate this cost as 10 percent of gross revenue¹⁰.

With these adjustments for depreciation and opportunity costs, the net returns to labor, management, and investment are as shown in Table 4. Positive returns on investment were effected by the group of larger vessels (on the average \$2,139, or 13.5 percent of total investment) and by the group of larger boats with more than 25 percent of revenue earned from other than lobster fishing (on the average \$1,589, or 18.5 percent of total investment). The remaining groups ended up with negative returns. In these latter groups, the amounts of gross profit as shown in Table 2 do not even compensate for the operator's labor. Nothing is left to pay for the management of his business, and his investment is earning no interest (Fig. 3).

In general, vessels and boats with

negative returns spent essentially less time fishing than those in the two groups showing profits. The smaller vessels (less than 35 feet), for example, were fishing only 72 days per season, as

compared to the average of 105 days per season for all vessels. It seems reasonable to conclude that fishing time is accountable for the difference between a profitable and unprofitable operation. With increasing age, breakdowns of a craft become more frequent, the requirements for repairs are intensified, and fishing time is cut down. Replacement of the old small craft with newer vessels and extending fishing (for other species) beyond the lobster season will most probably make this fishery more efficient.

The rather large number of vessels and boats with positive returns demonstrate that participation in this fishery can be made a profitable venture.

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MFR Paper 1137. From *Marine Fisheries Review*, Vol. 37, No. 4, April 1975. Copies of this paper, in limited numbers, are available from D83, Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235.

⁹This is a conservative figure compared to the amount of \$35-\$45 per day fishing, paid to a hired crewman.

¹⁰The authors considered this a reasonable estimate. The same estimate is used by Fredrick J. Smith, Oregon State University Extension Service, Marine Advisory Program, in *Understanding and Using Marine Economics Data Sheets*, S.G. N. 24, November 1973.

Spoilage and Shelf Life Prediction of Refrigerated Fish

LOUIS J. RONSIVALLI and STANLEY E. CHARM

ABSTRACT—Previous research by at least three separate investigating teams has shown that the spoilage of lean fish occurs at constant rates at temperatures above freezing and that there is a linear relationship between spoilage rate constants and storage temperatures. These findings are useful because they permit researchers and laymen to predict the shelf life of fish for any condition within the limits covered by the research. Mathematical or graphical methods may be used for arriving at the prediction. A device has been developed that simplifies the prediction.

SPOILAGE AND SPOILAGE RATE FACTORS

Two factors are prominent in the degradation of the quality of refrigerated foods and in the rate that spoilage occurs. These are spoilage bacteria and the temperature at which the foods are stored. However, other factors affect the spoilage process as well.

Seafoods are among the most perishable of foods, and it is important that we study the factors that affect their quality.

Bacteria

The role of bacteria in the spoilage of seafoods is well documented (Shewan 1962). The more active types of spoilage bacteria have been identified and their effects on the substrate have been defined (Shewan 1962; Castell and Mapplebeck 1952; Castell and Andersen 1948; Castell and Greenough 1957; Adams et al. 1964). The rate of spoilage is dependent on the number of bacteria (to a certain extent) and on the type of bacteria, since some types are more effective spoilers than others (Adams et

al. 1964; Lerke et al. 1965; Licciardello et al. 1967). However, the role of bacteria may be insignificant after a certain amount of bacterial activity has occurred. A recent publication (Huss et al. 1974) lends some support to the probable lack of direct relationship between bacterial numbers and spoilage rate.

Temperature

The role of temperature on the spoilage rate in foods, as it is for any chemical reaction, is well known. The temperature not only affects the rate of spoilage reactions, which involve both bacterial and autolytic enzymes, but it also affects the rate at which bacteria multiply. Thus, while the generation time for *Pseudomonas fragi*, a common fish-spoilage bacterium, is about 12 hours at 32°F, it is only about 2 hours at 55°F (Duncan and Nickerson 1961). Obviously, the rate of production of bacterial enzymes parallels to some degree the growth rate of bacteria, and the spoilage rate is in turn affected by the quantity of enzymes produced (at least up to a point).

The effect of temperature on the rate of spoilage of seafoods has been measured. Spencer and Baines (1964) reported that the spoilage rate of white fish is related approximately linearly to the temperature at which the fish are stored in the range -1° to 25°C. They

concluded that the effect of temperature on the spoilage rate was expressed approximately by the Arrhenius equation over a large part of the temperature range they employed. They reported activation energies of 15,000 to 18,000 cal/mole. James and Olley (1971) reported activation energies that were in agreement with those of Spencer and Baines (1964). Charm et al. (1972) reported similar findings for holding temperatures in a narrower range. They used an expert organoleptic panel of defined precision (Learson and Ronsivalli 1969). In this work, the activation energies reported were in a relatively narrow range at slightly above 18,000 cal/mole. The reduced range in the data by Charm et al. (1972) is attributable to the precision of the organoleptic panel used in the study. As in the earlier work, Charm et al. (1972) found a linear relationship between the spoilage rates and the temperatures of holding in the range 32°-46°F. They also found that when fish were held at a variety of temperatures, the spoilage rate for any given temperature remained constant regardless of the temperature sequence that was followed.

Other Factors

While the effects of both spoilage bacteria and holding temperatures on the spoilage of fish have received considerable study, little work has been done to identify the role of packaging and oxygen as significant factors in the spoilage rate of fish. Evidence of the possible role of oxygen was found in experiments involving the preservation of fish with radiant energy. When fish were packaged in gas-impermeable containers such as polyester and aluminum laminated pouches and metal cans, they had a longer shelf life than similar fish samples packaged in gas-permeable pouches such as polyethylene (Tinker et al. 1966). Measurements of oxygen in the headspace of containers demonstrated falling values for oxygen in the gas-impermeable containers (about 1 percent remaining in the headspace) within one month's time whereas the oxygen concentration in the headspace of the polyethylene pouches was equal to that in the atmosphere (Ronsivalli and Tinker 1969). It has been demonstrated that the more active spoilage bacteria normally found in fish are

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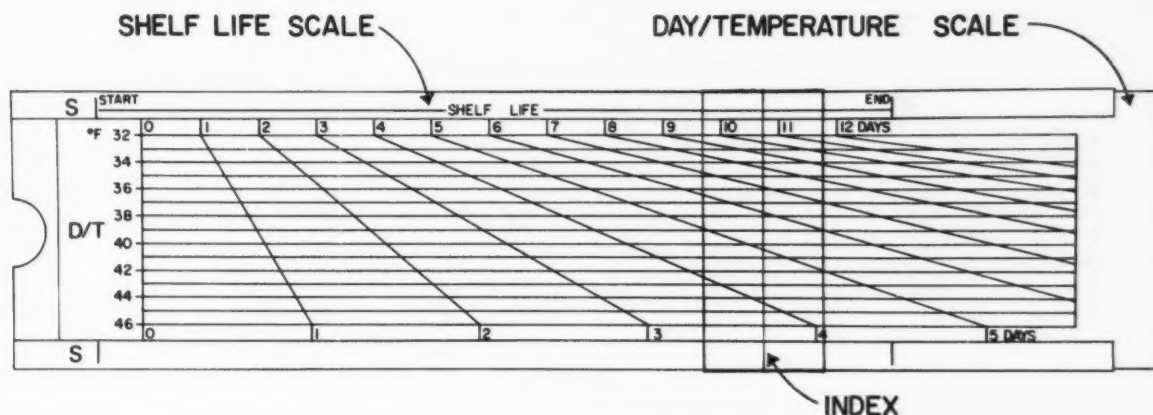


Figure 1.—The shelf life prediction slide rule, or predictor.

aerobes (Licciardello et al. 1967; Sinskey et al. 1967). Obviously, since spoilage bacteria require oxygen to metabolize, the spoilage rate in fish, due to their enzymes, is a function of the oxygen availability in the substrate. It should be pointed out that a second role of oxygen, in which it enters into adverse chemical reactions that result in rancidity or discoloration, is not of significance at the storage temperatures cited here. Also, it should be pointed out that only the enzymes of specific bacteria are responsible for the common spoilage of fish. Flesh enzymes and enzymes of other bacteria are relatively insignificant.

Even when oxygen is removed from packaged fish, the gas permeability of the container is important to the survival or inactivation of bacteria. When containers are impermeable to gases, not only do they prevent the entrance of oxygen, but they might also prevent the release of bacteriostatic or bactericidal gases resulting from bacterial metabolism.

At least one other factor that affects the reaction rate is the amount of substrate surface exposed to bacteria. Thus, one would expect that when the surface to volume ratio is small as in whole large fish, the spoilage rate of the whole mass will be relatively slow and when the surface to volume ratio is large as in fillets of small flat fish, the spoilage rate of the entire fillets will be relatively fast. Practical experience supports this. In the case of minced fish, which is becoming popular, the surface to volume ratio is very large and, very likely, it will have a short shelf life unless it is kept

frozen or spoilage is controlled by some other means.

This discussion of oxygen, gas permeability of packaging, and surface to volume ratio of substrate is made only to call attention to these factors. In fact, there may be other factors in addition to those cited above that affect the spoilage of fish as well as the rate at which they spoil. None of these factors were considered in any of the research cited above or reported herein because refrigerated fish are not, as a rule, packaged in gas-impermeable containers—nor are they comminuted except when they are to be made into frozen blocks. Thus, while bacteria and storage temperature are the decisive factors in the spoilage of refrigerated fish, we must remain alert to recognize other possible factors that may be involved.

SHELF LIFE PREDICTION

Although the spoilage of seafood undoubtedly involves a number of interactions among many of a variety of reactants that may be present in them, a significant amount of data in the literature appears to support the thesis that one of the reactions must be limiting with the consequence that it controls the spoilage rate. While it is generally accepted that the spoilage rate is dependent of the activity of the spoilage bacteria (the activity of bacteria is generally expressed as a function of the integral of the area under the bacterial growth curve), our work suggests that this is true only up to a point. That is, the spoilage rate depends on the number of

spoilage bacteria until a level of activity has been reached such that the spoilage rate is no longer affected by an increase in the bacterial numbers.

Mathematical and Graphical Methods

It has been demonstrated in the literature cited above (Spencer and Baines 1964; James and Olley 1971; Charm et al. 1972) that the shelf life of fish held at temperatures within limits may be predicted with the use of the Arrhenius equation:

$$K = Ae^{-H/RT}$$

where: K = rate of spoilage,
 A = orientation factor,
 e = mathematical constant,
 H = energy of activation,
 R = gas constant, and
 T = temperature (absolute).

Since spoilage can be defined as the limit of quality, the rate can be used to predict the time required for the limit to be reached.

In addition to the mathematical methods for predicting the shelf life of fish products, graphical prediction methods have been proposed by James and Olley (1971) and Charm et al. (1972).

Olley and Ratkowsky (1973) discussed the use of an electronic universal integrator for determining the shelf life of fish and possibly other foods. The device, a temperature function integrator and multipoint telemeter, was developed by Nixon (1971).

A Simple Prediction Device

Although the prediction methods cited thus far are suitable for the purpose, it appeared that a simple, inexpensive integrator that could be used by the layman should be possible (Fig. 1). The graph described by Charm et al. (1972) was used as the basis for a shelf life predictor (Ronsivalli et al. 1973) that was manufactured from plastic relatively inexpensively, is simple in operation, and permits the prediction of the shelf life of fish irrespective of the variety of temperatures (in the range 32°-46°F) to which fish might be exposed and irrespective of the sequence of the exposures.

The predictor consists of three parts: 1) an index, 2) a shelf life scale, and 3) a temperature scale. By a series of simple operations that accumulates the shelf life that has been used up, the remaining shelf life at any temperature can be predicted. The predictor is especially useful for buyers and distributors of fish products who need the kind of information that the predictor can supply quickly and relatively accurately. One of the observations that is noted through the use of this device is the implied economic benefit to be realized by keeping seafoods at as low a temperature as possible. For example, the shelf life at 32°F is seen to be about twice that at 42°F.

As with any other prediction method, the accuracy of the predictor requires that the quality of the fish is either known at some point or that its history (the temperature(s) and the time at each temperature at which the fish has been kept from the moment it was landed on board the vessel) is known.

Operation of the device is demonstrated by Ronsivalli et al. (1973).

DISCUSSION

Our study included storage temperatures in the range 32°-46°F. In that range, the rates at which fish spoiled appeared to be linearly related to the temperature at which they were stored. Our reasons for selecting that temperature range were: 1) we felt that temperatures below 32°F would be difficult to maintain, and we might run the risk that the possible crystallization of some water might affect our results, and 2) our experience had shown that 46°F is about the upper limit of the temperature

range of domestic refrigerators and of commercial display refrigerators. In addition, we did not believe that the effort at higher temperatures could be justified in terms of practical application because of the short shelf life of the product at higher temperatures. Although studies by others indicated a linear relationship between spoilage rates and temperatures over a wide range, Olley and Ratkowsky (1973) stated that this relationship is not linear at temperatures above 46°F. We believe that from an academic point of view, this discrepancy might deserve more study. However, from a practical point of view, there is little to be gained. The effort would be better spent towards establishing the case for low temperature holding. In our view, the temperature at which fish are held should be strictly controlled up to the point when the products are purchased by the consumer.

We must reiterate that the use of packaging may introduce new variables depending on the size (bulk) of the package and the gas permeability of the container.

Finally, it should be emphasized that the predictor was based on data obtained from cod. Although experiments were not conducted to test it for other fish, we have good reason to believe that the difference in the shelf lives among other lean species of fish is relatively small and certainly within the inherent error of the device. The bulk of the pertinent literature supports this thesis.

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Fish Product Inspection, Standardization Understanding Is Reached by DOC and FDA

The Department of Commerce's National Oceanic and Atmospheric Administration has announced an agreement with the Food and Drug Administration concerning the inspection and standardization of fishery products processed in the United States.

The FDA is responsible under the Food, Drug, and Cosmetic Act to insure that foods are safe and wholesome and that products are honestly labeled.

The National Oceanic and Atmospheric Administration is authorized by the Agricultural Marketing Act and the Fish and Wildlife Act to develop and implement quality grade standards for fishery products and to improve health and sanitation standards in the industry. NOAA also has the authority to conduct both plant and product inspection for fishery processors through a voluntary inspection program available to the industry.

This agreement will benefit both consumers and industry by extending fishery products inspection activities to more products and facilities. NOAA's inspection service will not diminish FDA's authority to inspect but should minimize FDA inspections in establishments under NOAA contract inspection.

In the Memorandum of Understanding between the two agencies, FDA recognizes the expertise of NOAA's National Marine Fisheries Service in the field of fishery products quality and sanitary processing. FDA also recognizes that plants under contract to NMFS' voluntary inspection program are subject to inspections which insure compliance with the Federal Food, Drug, and Cosmetic Act.

Since both agencies have certain common or related aims in carrying out their respective regulatory and service activities, the agreement defines the working arrangements which will enable each agency to administer more effectively its responsibilities relating to inspection and standardization of fishery products. Some of the areas for cooperative action identified in the agreement include joint consultation on recognized problem areas, period-

ic joint program planning, product retention and recalls, and training.

"Our agreement with FDA comes at a most appropriate time," said Joseph Slavin, Associate Director, Office of Resource Utilization, NMFS. "We have only recently expanded and modernized the inspection services that we can offer to the industry. We have developed new services, overhauled existing services to fit the needs and pocketbooks of smaller firms, and added greater flexibility to handle new business. These recent changes and our agreement with FDA makes it more attractive for a firm to use our services."

Permits Issued Under Marine Mammal Law

The Commerce Department's National Oceanic and Atmospheric Administration announced in mid-December that three general permits, which will require U.S. fishermen to take special precautions to protect marine mammals taken incidental to certain commercial fishing operations, were issued to the United Fishermen of Alaska, Juneau, Alaska, on behalf of all U.S. fishermen.

The general permits for three fishing gear categories were issued in compliance with the regulations issued under the Marine Mammal Protection Act of 1972. The Act was passed to protect, maintain, and if necessary rebuild the populations of marine mammals and, among other things, restricts the taking and importing of marine mammals and marine mammals products. The word "take" means to harass, hunt, capture, or kill or attempt to harass, hunt, capture, or kill any marine mammal.

Because there are times when fishermen might unavoidably take marine mammals during normal fishing operations, regulations provide for the issuance of general permits and certificates of inclusion which allow fishermen to take marine mammals incidental to their commercial fishing operations.

Conditions of the general permits and the certificates of inclusion under the

permits require that U.S. commercial fishermen take special measures to avoid seriously injuring or killing marine mammals in their fishing operations. If a marine mammal is killed or seriously injured it must be reported to the National Marine Fisheries Service within a specified time. The report must contain the location, time, and date of the injury or death as well as the identity, number of marine mammals involved, and the circumstances which led up to and caused the death or serious injury.

The three general permits were issued to the United Fishermen of Alaska by the National Marine Fisheries Service under the general categories relating to: encircling gear (seine fishing other than yellowfin tuna), stationary gear, and other gear such as hook and line used in commercial fishing operations. The permits are valid until 31 December 1975, unless amended, suspended, or revoked by the Director of NMFS. The terms and conditions of the general permits and the related certificate of inclusion may be modified to conform to amendments made in the regulations.

Now that the general permit has been issued, individual commercial fishermen in these gear categories who incidentally take marine mammals in the course of fishing operations must apply for a certificate of inclusion under the general permits. Applications for the certificates of inclusion are being accepted at the National Marine Fisheries Service's Regional Offices in Seattle, Wash.; Terminal Island, Calif.; Gloucester, Mass.; St. Petersburg, Fla.; and Juneau, Alaska.

Clam Stocks Increase Off Virginia's Coast

Surf clam populations have become commercially abundant off the Delmarva Peninsula and the Virginia coast according to the National Oceanic and Atmospheric Administration's National Marine Fisheries Service.

A surf clam survey made by the Commerce Department agency's Oxford, Md., laboratory, showed that the center of abundance of the clams has moved from the New Jersey coast to the waters off the Delmarva Peninsula. The clams are also being found more often and in greater quantities in the

Virginia-North Carolina area than was recorded in an earlier survey.

John Ropes, scientist from the Oxford laboratory and Party Chief for two cruises this past summer, states that the shift in concentration is probably the result of more favorable climatic conditions in recent years in the Delmarva, Virginia, and North Carolina areas. The fishery for the clams has increased in the area, with a corresponding decrease in the fishery off New Jersey.

NOAA Survey of Southeast Coastal Waters Completed 13 Years Ahead of Schedule

The National Oceanic and Atmospheric Administration reports that it has completed in two years a survey of a 38,000-square-nautical-mile area of coastal waters off the Carolinas, Georgia and northern Florida which has previously been programmed for completion in 1988. The survey, dubbed SCOPE (Southern Coastal Plains Expedition), will provide marine information on the coastal plain region which will aid Federal, state, local and private agencies in making decisions on environmental problems.

In compressing the 15-year survey into two years, NOAA used four ships, a hydrographic field party, land support units and an air photo mission. The ships and hydrographic party covered approximately 76,000 miles, equivalent to more than three times around the globe, in carrying out their surveys.

The SCOPE survey, which began in January 1973 and was completed this month, served as a prototype for similar concentrated surveys in other major coastal areas as funds and facilities become available.

Processing of the data has also been speeded up in order to expedite the release of information for environmental development studies, such as ecology, pollution control and marine engineering, and for nautical charts. Considerable data from last year's operation are already available and data from this year's survey will be available in about 12 months. Ordinarily, the processing of the many thousands of pieces of data in a survey of this type would take about 5 years beyond completion of the field work.

The coastal waters covered by the survey extended from Cape Hatteras,

The surf clam is the most commercially important clam in the United States, and its range of distribution is restricted to the Middle Atlantic area of the east coast. Over 82 million pounds of surf clam meats, valued at over \$9 million were landed by commercial fishermen in 1973 in the United States. They were used primarily for soups, chowders, and fried clams by large commercial users such as the restaurant chains and institutions.

N.C., to the vicinity of Cape Canaveral, Fla., and out to sea as much as 60 miles. The water depths surveyed ranged from the surf zone to 600 feet.

SCOPE was carried out by facilities of NOAA's National Ocean Survey, including the NOAA ships *Whiting*, *Mt Mitchell*, *Peirce* and *Ferrel*. The survey by the Commerce Department agency included surveys of the bottom topography, tidal currents, tide measurements and studies of the sea's physical properties—such as salt content and water temperatures—along the coast and in the Gulf Stream. Aerial photos were taken of the coastline to delineate the high and low water lines for use in the compilation of nautical charts.

The data and products that are available, or will be next year, from the survey include: Tidal current data; shoreline maps; aerial photographs; and survey sheets.

Tidal current data will be available in various forms, including magnetic tape, printouts, computer plots and data analysis forms. In due course, the data will be incorporated in the tidal current tables published by the agency. The data provide information on the speed and direction of the water that flows in and out of the estuaries, information essential to coastal planning, especially in determining the dispersion of pollutants.

Shoreline maps depict the high and low water lines as determined by aerial photography. The maps are important in determining shoreline boundaries.

Aerial photographs can be used by coastal planners for studies of the shoreline and for any type of shoreline construction. The boundaries (the high and low water lines) along the coast can

be physically seen, although it may be necessary at times to enlarge segments of the photos to achieve this.

Survey sheets provide in great detail (much more so than on nautical charts) ocean soundings along the coast. The information is important to commercial shipping, recreational craft and coastal engineering. It also provides a picture of the sea bottom, useful in almost any study of the area, whether for engineering or scientific purposes and in connection with petroleum research and the recovery of minerals on the continental shelf.

Other data gathered in the survey will be reflected later in updated nautical charts and tide and tidal current prediction tables. These data are important to ship navigation and all types of coastal engineering, including the construction of buildings and other structures, such as piers and seawalls.

Queries concerning the availability of SCOPE information and products should be addressed to the National Ocean Survey, Office of Marine Surveys and Maps (C3), Rockville, MD 20852.

NOAA Has New Jersey Inshore Water Data

The Public Service Electric and Gas Company of New Jersey has released to the Department of Commerce's National Oceanic and Atmospheric Administration environmental data collected in the inshore waters of New Jersey, north of Atlantic City (centered at lat. 39° 28'N and long. 74° 15'W).

The data, deposited in NOAA's Environmental Data Service, was collected as part of a site survey for a proposed nuclear generating station by several research groups under contract to the Public Service Company. Data sets consist of six biological reports, two geological/geophysical reports, three water quality (chemistry) reports, 13 physical oceanographic reports (currents, waves, tides, hydrography), 98 analog seismic reflection profiles, and digitized depth, temperature, salinity and current observations.

The reports contain detailed information on:

- 1) Ecological studies: life histories and migrations of some important fishes, distribution of eggs and larvae of fishes, results of seine and trawl collections, sports and commercial fisheries, invertebrates, shell fish-

eries, other marine and estuarine organisms, organisms associated with artificial reefs, problems and consequences of power plants on marine ecology.

2) Physical properties of wave masses: Waves: daily wave statistics, joint distribution of significant wave heights, wave-rider data analyses, normalized wave energy spectra from wave-rider records, summary of wave records.

3) Currents: currents vs. direction, histograms, plots, profiles, computer printouts of current speed vs. direction, surface and subsurface drogus tracks, dye dispersion.

4) Tides: summary and analyses of tide recordings.

5) Hydrography: seasonal and daily

variations in water temperature as a function of depth, depth-temperature-salinity profile summaries.

6) Geology/Geophysics: bathymetry, seismic reflection profiling and sediment analysis.

The data in scientific report form and analog form are available from the Environmental Data Service on loan or microfilm copy. Automated data are available as magnetic tape copy or machine listing. Write: National Oceanographic Data Center, Environmental Data Service, National Oceanic and Atmospheric Administration, 3300 Whitehaven St., Washington, DC 20235, or phone (202) 634-7441.

Porpoise Mortality Rate Reduction of 50 Percent Picked by Commerce Department

The Commerce Department has set a 1975 goal of a 50 percent reduction below the 1974 level in the rate of porpoises killed in U.S. yellowfin tuna fishing operations, and has issued regulations designed to achieve that goal, Robert W. Schoning, Director of the National Marine Fisheries Service, has announced.

Achievement of this goal will mean a reduction in porpoise mortalities from about one per ton of yellowfin tuna caught in sets on porpoises in 1974 to approximately one per two tons caught in 1975. Yellowfin tuna sometimes school under porpoises and fishermen set their seines around schools of porpoises to capture the tuna beneath them. A reduction from an estimated 117,000 porpoises killed in 1974 to approximately 58,000 in 1975 will result if U.S. tuna fleets set on porpoises at about the same rate in 1975 as they did in 1974, Schoning said. The precise number will depend upon the number of sets on porpoises and the tons of tuna taken.

"Our goal is to achieve the purposes of the Marine Mammal Protection Act of 1972, which required that the porpoise mortality and serious injury rate be reduced as closely as possible to zero within the state of science and technology," Schoning said. "The new regulations are expected to accelerate the downward trend of porpoise mortality experienced in recent years without inflicting severe economic damage on the American tuna fishermen."

He also pointed out that additional porpoises are killed by foreign tuna

fishermen who operate under no regulations that protect porpoises. "There is a need to insure that foreign fishermen, too, will make a greater effort to protect the porpoises," he said, "and our government will be taking further steps to encourage other governments to reduce porpoise mortality."

The three changes in the current regulations governing U.S. commercial yellowfin tuna purse seine fishing operations, effective 3 January 1975 are:

1) All U.S. yellowfin tuna purse seine fishermen holding certificates under a general permit must attend training sessions to ensure that they are personally aware of the provisions of the Marine Mammal Protection Act of 1972, regulations based on the Act, and methods they must use to protect porpoises;

2) The fishermen must use an additional rescue technique for porpoises, by stationing two men in a small boat close to the net and readily available to extricate and release all porpoises entangled in the net;

3) A technical revision in the wording of existing regulations concerning corkline net hangings clarifies its applicability to only a part, rather than the entire net.

The three changes in the regulations are the most recent step in the continuing effort of the National Marine Fisheries Service to reduce the porpoise mortality rate. For more than two years, the National Marine Fisheries Service has worked with conservationists, protectionists, the fishing industry, the Marine Mammal Commission and its scientific advisors to establish regulations and improve fishing

methods and gear to protect marine mammals, especially porpoises which are incidentally killed during yellowfin tuna purse seine fishing operations.

Regulations to protect porpoises during commercial yellowfin tuna fishing operations became effective on 30 September 1974. These regulations established a general permit system structured by five fishing gear categories. Under this system, fishing vessel masters or other persons in charge of fishing operations must obtain a certificate of inclusion under a general permit and comply with the terms and conditions of the regulations and the general permit.

All holders of a certificate of inclusion must, among other things, return all captured marine mammals to the water immediately and take every possible step to minimize killing and injuring the mammals. They are not permitted to set purse seine nets around porpoises when, in their judgment, wind, sea condition, visibility or the number of fish, porpoises, or both in the net would prevent proper release procedures from being used. Certificate holders are also required as a last resort to open a purse seine net already set on porpoises, if, in their judgment, this is the only way to minimize mortality. They must also maintain daily logs of all sets which include porpoises or other marine mammals, maintain their equipment in good order, and use auxiliary boats to hold the nets open so porpoises will not become trapped or entangled in the net. A violation of any of these regulations is grounds for suspending or revoking a certificate of inclusion.

The three changes in the regulations were published in the *Federal Register* on 3 January 1975. They are based on recent research conducted by the NMFS and on the results of proposals made at an informal public hearing held by the National Oceanic and Atmospheric Administration on 10 and 11 December 1974, attended by representatives of the fishing industry, conservationist and protectionist organizations, and government agencies.

"These new changes are added to the many other stringent requirements not yet thoroughly employed by the entire fleet because they were implemented toward the end of the 1974 fishing season," said NMFS Director Schoning. "There is no simple, single, right answer to the problem. We are continually

trying to improve the regulations and we welcome recommendations and suggestions that will improve the program."

Approximately 30 suggestions or recommendations for changes in the regulations were made at the recent hearing," said Schoning. "They ranged from minor technical word changes to proposals to stop all seining of tuna that have schooled beneath porpoises. Many of the suggestions are already in effect or being followed; others will require additional rule-making procedures. Still others are being studied for possible further action or modification. All suggestions and recommendations were studied and evaluated, and much information was obtained from the hearing that will contribute toward improvements in the program."

Additional informal public hearings in regulations are tentatively scheduled later this year. Regulations may be changed, deleted, or added, based upon any new data. "We will monitor the progress being made in 1975 to evaluate the effectiveness of our regulations and ensure that every effort is made to meet the goal," said the NMFS Director.

Research will continue while data are being collected on the effectiveness of the regulations. "Much is at stake," Schoning said. "Porpoise can be given realistic protection while purse seining for yellowfin continues. But, it will require the cooperation of everyone involved."

Russia Will Pay For Lost Lobster Gear

The Commerce Department's National Oceanic and Atmospheric Administration has announced that the Soviet Union has agreed to pay \$11,400 to the R & G Fisheries of Tiverton, R.I. The payment will be made for loss of gear and financial hardship caused when Soviet trawlers destroyed the company's lobster traps while trawling through a well marked area in October 1971.

The USSR agreement to pay was reached during a meeting of the U.S.-USSR Fisheries Claims Board which was established this year to hear claims submitted to it for damages caused by fishing vessels of either country. Members of the board include Carmen J. Blondin, of NOAA's National Marine Fisheries Service; Clinton J. Maguire, U.S. Coast Guard; and

Y.A. Znamenskiy and A.G. Afanasyev of the Soviet Union.

R & G Fisheries alleged that on the morning of 9 October 1971, their fishing vessel, *Seven G's*, found numerous Soviet trawlers towing through their lobster traps in an area marked with flags, buoys, and radar reflectors. The *Seven G's* removed as many undamaged lobster traps as possible and returned to port. On October 27, the *Seven G's* returned to the area and found that the rest of her gear and traps were gone. A total of 210 lobster traps and accompanying gear was lost. Owners of R & G Fisheries stated that they were forced to curtail offshore lobstering for the remainder of the season because of the incident.

The incident occurred approximately 70 miles off the northeast coast of the United States.

Surface Sediments Found Polluted in Los Angeles and Long Beach Harbors

Most of the surface sediments in the Los Angeles-Long Beach Harbor area and in the San Pedro Basin contain pollutants in varying concentrations, according to an 18-month study of the San Pedro Bay by Sea Grant scientists from the University of Southern California.

Purpose of the study was to provide baseline information on the environmental effect of alternatives for disposing of dredge spoil, such as land fill or open water dumping. The scientists concluded that carefully planned, restricted dredging of certain areas of the San Pedro Bay harbor complex would probably be beneficial, provided that the dredge spoil is properly disposed of. If dumping sites are carefully chosen, they said, minimum damage will occur.

The possibility of dredging part of the Los Angeles Harbor to create a deep-water port has been under consideration for several years by the Los Angeles Harbor Department—which contracted with USC Sea Grant Harbor Projects for the study—and the U.S. Army Corps of Engineers. The Commerce Department's Sea Grant Program at USC provided the interdisciplinary team to undertake the analysis, and additional funding was provided by the Allan Hancock Foundation, the Corps of Engineers, and the National Oceanic and Atmospheric Administra-

tion through its Office of Sea Grant.

Headed by Dorothy Soule and Mikihiro Oguri who directed field sampling, and Kenneth Y. Chen and James C.S. Lu of USC's Environmental Engineering Programs, who performed the chemical analyses, the Sea Grant team also included scientists from Immaculate Heart College, Occidental College, and California State University at Long Beach.

After taking hundreds of samples of harbor bottom sediments throughout the 22-square-mile area and adjacent waters to Catalina Island and analyzing them for some 35 substances, the Sea Grant scientists produced a list of contaminants that reads like a Who's Who of Chemical Villains: heavy metals such as lead, mercury, and cadmium; organic pesticides such as DDT and aldrin; a class of toxic chemicals known as PCB's (polychlorinated biphenyls); organic materials, and nitrates and phosphates from industrial and domestic sewage.

Chen, an Associate Professor of Environmental Engineering at USC, likened the harbor bottom to a vast chemical laboratory whose workings are not known. "The silts and muds may act as a sort of storehouse or 'sink' for some pollutants," he said, "trapping them chemically and preventing their release into the environment. Under some special environmental conditions, the sediments may have the opposite effect, actually forming new compounds and thereby acting as a new source of pollution."

In addition, he said, when a harbor bottom is dredged and the spoil is dumped offshore, the transported sediment may change its characteristics from a beneficial "sink" to a new and dynamic chemical system that may cause an unknown environmental effect by releasing the pollutants attached to the dredged material.

Because the relationships between sediment and pollutants and between pollutants and the environment are not yet well understood, Chen draws a cautious warning. "There are very few remedies available to undo the pollution of the past," he said, "since the selective removal of pollutants from sediments is almost impossible. Emphasis must be placed on preventing these types of irreversible processes from occurring in the first place."

The study shows that the Los Angeles County Sanitation District sewer outfall at White's Point has been the major source of trace metals and chlorinated pesticides such as DDT, while the harbor complex contributes more of the PCB's. Los Angeles Harbor is relatively contaminated in comparison to the pollution in San Pedro Bay.

The report is available from Marine Advisory Services, USC Sea Grant Program at the University of Southern California.

SALMON VACCINATED TO PREVENT DISEASE

Salmon reared in floating pens are being vaccinated to prevent disease, according to the National Oceanic and Atmospheric Administration.

National Marine Fisheries Service scientists at the Northwest Fisheries Center Experiment Station, Manchester, Wash., are developing vaccines and equipment to immunize coho and chinook salmon against the greatest killer of salmon in salt water, the *Vibrio* bacterium.

Growing salmon in pens both for commercial use and for the management of recreational fisheries is widespread. At the Commerce Department agency's Manchester laboratory, NMFS personnel have assisted in establishing salmon rearing projects from California to Alaska, from New Hampshire to Nova Scotia, and on the coast of France.

The rapid expansion of commercial saltwater rearing in Puget Sound with over 300 metric tons of coho salmon produced in the first half of 1974, has stimulated worldwide interest. In addition, the Washington State Department of Fisheries releases more than 100,000 saltwater-reared chinook and coho salmon into Puget Sound each year for the benefit of recreational fishermen.

The early development of a *Vibrio* vaccine was pioneered under a NOAA sponsored Sea Grant program at Oregon State University, Department of Microbiology, and field trials were conducted on coho and chinook salmon by the Fish Commission of Oregon.

Mortalities from disease can approach 100 percent if saltwater-reared stocks are not treated. However, fish infected with *V. anguillarum*, the most common virulent species of *Vibrio*,

normally respond to orally administered tetracycline antibiotics. This method of treatment, however, is expensive and slow. Many fish die before the antibiotics take effect.

NMFS scientists have found that a single injection of heat-killed cells cultured from a Puget Sound strain of the disease is adequate to provide at least 90 percent protection to the young coho salmon from early summer through late fall. Up to one-half million young salmon can be injected with a little over two pounds of vaccine.

The experimental injection equipment, made from "off-the-shelf" material, consists of flasks to hold the vaccine and plastic tubing through which it flows by gravity into repeating syringes. The heat-killed cells are suspended in a saline solution and injected into the posterior body cavity of the fish.

With minimal training, a worker can vaccinate 600 to 1,000 fish per hour. Cost of the vaccine and labor ranges from \$300 to \$700 per 100,000 fish, considerably less than the cost of administering the vaccine orally.

Several weeks after the fish are vaccinated, they develop detectable agglutinating antibodies against the disease. Rather than maintaining production of antibodies, the scientists found that antibody production in the fish declined as the season progressed. Although antibody production can be restimulated with the followup vaccinations, it is expensive. The NMFS scientists are now testing media that will allow the vaccine to enter the fish more slowly so that it will continue to stimulate antibody production for a longer period.

Seaweed Tank Farms Believed Profitable

A two-acre "farm" growing a common red seaweed found in the Florida keys would be a paying proposition, says a biologist at the University of South Florida, Tampa. Working under a Sea Grant provided by the National Oceanic and Atmospheric Administration, Clinton J. Dawes calculates that intensive tank culture of the Florida seaweed called *Eucheuma*—much in demand for commercial extracts—would yield up to \$9.72 per square meter per year.

A "farm" of seaweed-growing tanks

taking up a little over two acres of land (about the size of three football fields) would thus be expected to bring the growers a gross of about \$85,000 a year.

The three-year Commerce Department-supported study points out that harvesting the red algae under field-grown conditions would yield only about \$0.16 per square meter, meaning that more than 12 acres of area would be required to yield around \$8,000 annually.

"The 60-fold increase in gross revenue by tank culture will have to be considered in the light of such costs as tank construction, water movement, and temperature control," Dawes notes. "However, based on our study of the ecology, biochemistry, and economics of the plant, mariculture seems feasible and desirable." He points out that only after a pilot plant has been established can a sound cost vs. profit balance be struck.

The common Florida red algae, *Eucheuma isiforme*, is one of several kinds of seaweed that, when properly dried and processed, yield an important chemical colloid known as carrageenan. Carrageenan is used principally as a thickener, stabilizer, and gelling agent in food and food products, pharmaceuticals, cosmetics, paints, and textile sizings. In recent years the carrageenan industry has grown more rapidly than that of any other seaweed product, tripling from about 2,200 metric tons in 1960 to more than 8,640 metric tons in 1971. Nearly half is produced in the United States with a value of more than \$16 million.

"There is only a limited supply of natural populations of seaweeds that yield carrageenan," says Dawes. "Collection of these seaweeds is relatively primitive and is mostly dependent upon natural wild populations, thus aggravating the limited natural supply. Not only growth, but the survival of the carrageenan industry will depend upon a reliable and increasing source of raw material." Cultivation of carrageenan-producing seaweeds is now being carried out in the Philippines.

Dawes points out that because most large populations are already being harvested in areas throughout the world, any further increase in production must come from development of mariculture procedures.

The cost of the dried seaweed has

risen as natural populations are over-harvested. In 1963 the cost of a kilogram of clean, dried Canadian *Chondrus* (another kind of carrageenan-bearing seaweed) was \$0.22, while ten years later, in 1973, the cost for a kilogram of either *Chondrus* or central Pacific *Eucheuma* varied from \$0.66 to \$1.10, depending upon the purity of the sample.

The common Florida seaweed was selected by Dawes as most promising for mariculture because it is easily accessible, has a high yield of carrageenan, and is perennial with a stable life history. The shallow water form of the plant, found in the Florida Keys, was the form selected.

This seaweed is found in open, exposed marine waters with tidal currents of up to half a knot and where the bottom is limestone. Salinities are rela-

tively high and nutrient levels relatively low. Longevity studies show that individual plants of certain forms in the Florida Keys will remain throughout the year. Growth rates are highest in the spring, summer, and early fall.

At present wild populations of the plant are harvested in the central Pacific at a rate of about 4,000 metric tons per year. The world price for clean, dry seaweed is now greater than \$350 per metric ton. The major factor limiting its harvests is the availability of the wild material, which fluctuates by season and because of storm damage and site depletion.

"Availability of raw material sources for the production of carrageenan is of great concern," says Robert D. Wildman, Director of Project Support Programs of NOAA's Office of Sea Grant.

"Owing to changing political climates imports of seaweed from other countries are not always dependable, and in any case they aggravate the U.S.' balance of payments problem. We are therefore looking to ways to increase domestic sources."

Dawes proposed the use of plastic or fiberglass-coated plywood containers with about three square meters of surface area and using compressed air for water circulation. In a tank of this size about 20 kilograms (44 lb) of plant material could be allowed to cycle for about 30 days, increasing in size to about 36.2 kilograms (almost 80 lb). This would reduce in dry weight, to about 7.24 kg (almost 16 lb). Ten such harvests could be carried out each year in each tank using plants collected from the wild or grown under controlled conditions.

Foreign Fishery Developments

Japan's 1973 Marine Catch Up 3 Percent

The Statistics and Information Department of the Japanese Ministry of Agriculture and Forestry in early October 1974 published catch statistics of

1973 for the marine fisheries of Japan. The statistics show that the marine catch during January-December 1973 totaled 9,749,000 metric tons, an in-

crease of 295,000 tons or 3 percent above 1972. Significant gains were recorded for sardines, saury, and skipjack tuna, while sharp declines occurred in the common squid ("surume-ika"), atka mackerel and kelp production.

The most important species landed, in terms of quantity, was Alaska pollock, with a catch of 3,023,000 metric tons. However, compared with 1972, landings were down by 12,000 tons, thus ending the consistent uptrend recorded in recent years. Second in importance was Pacific mackerel, with 1,134,000 tons, down 56,000 tons or 5 percent from 1972.

Tuna (excluding skipjack) landings were 328,000 metric tons. Landings since 1970, the year when a low of 291,000 tons was reached, began to increase annually by over 10,000 tons, recording 308,000 tons in 1971 and 318,000 tons in 1972. Skipjack tuna landings, which totaled 320,000 tons, were 44 percent ahead of the 1972 catch of 223,000 tons and up 87 percent over the 171,000 tons for 1971.

Source: *Suisan Tsushin*.

Coastal Currents Studied off Norway

Norwegian researchers began a broadly-based investigation of the coastal current off that country's coast early this year. Questions studied by the project include the consequences of the oil industry in the North Sea, the condi-

Japan's marine fisheries catch¹, 1973.

Species	Comparison 1973 Over 1972		Species	Comparison 1973 Over 1972	
	Catch 1,000 mt	Percent		Catch 1,000 mt	Percent
Tuna			Alaska pollock	3,023	100
Bluefin	47	101	Cod	109	124
Albacore	93	101	Rockfish	101	115
Bigeye	102	104	Atka mackerel	115	64
Yellowfin	68	100	Croaker	45	107
Yellowfin (young)	18	132	Sea bream	30	92
Total, tuna	328	103	Dolphin fish	15	160
Skipjack			Mullet	6	75
Skipjack	320	144	Other fish	1,248	—
Frigate mackerel	34	109	Shrimp	63	108
Total, skipjack	354	139	Crabs		
Billfish			King	5	52
Striped marlin	13	76	Tanner	26	62
Swordfish	14	100	Blue	3	205
White marlin	11	98	Other crabs	33	129
Sailfish	6	99	Total, crabs	67	85
Total, billfish	43	89	Squids		
Salmon	136	114	Common squid		
Sardines	731	139	("Surume-ika")	347	75
Jack mackerel	128	84	Cuttlefish	12	80
Pacific mackerel	1,134	95	Other squids	127	106
Saury	406	206	Total, squids	487	81
Sharks	40	94	Octopus	73	109
Herring	83	133	Sea urchin	26	115
Yellowtail	53	107	Shellfish	261	84
Flatfish			Seaweeds		
Flounder	381	109	Kelp	131	86
Bastard halibut	9	108	Other seaweeds	90	—
Total, flatfish	390	109	Total, seaweeds	221	95
			Other marine products	34	—
			Grand total	9,749	103

¹Some figures may not add to the listed totals due to rounding.

tions promoting the growth and development of fish, the effects of the regulation of watercourses and the affect of the current on the seabed and the transportation of sediments. The project is interdisciplinary, and nine research institutes are at present involved. Led by Martin Mork of the University of Bergen's Geophysical Institute, the project is planned to last five years, although it may continue beyond this time.

It is also planned to map the exchange of water in the fjords along the coast and the influence of the coastal current on climatic conditions. These studies will, it is hoped, provide the authorities with an improved basis for arriving at decisions on such questions as the development and regulation of watercourses. Studies off northern Norway are to be intensified to provide a large body of scientific data before exploration for and exploitation of petroleum reserves begins in these waters.

There will also be cooperation with an international research project involving all the countries bordering the North Sea. The primary aim of this project is the charting of the inflow and outflow of water in the North Sea. The Norwegian researchers are to concentrate in particular on the northern and northeastern parts of the North Sea.

Papua New Guinea Puts Higher Tax Assessment on Foreign Fish Firms

Three Japanese firms and one U.S. firm engaged in experimental skipjack tuna fishing for the Papua New Guinea Canning Company in late 1974 were notified by the government of Papua New Guinea of new tax measures applicable to their catches. Reportedly, the notification called for a 9 percent corporation tax assessment on all shipments of tuna catches taken by those firms since the beginning of their fishing operations in 1970, and a 5 percent export tax on all shipments from 18 November 1974.

At a meeting held in Tokyo on December 12 with Papua New Guinea's Natural Resources Development Minister, the participating Japanese fishery firms (Kyokuyo, Hokoku Suisan, and Kaigai Gyogyo) expressed objection to the tax measure and requested reconsideration, stating they

could not possibly comply with the requirements since the fishing ventures, which are being conducted at huge costs and great risks, are still not producing profits for them. They claimed that the assessments would not only make it impossible to continue the fishing operations but also thwart the planned establishment of a cannery at Madang. The Papua New Guinea Minister was said to have agreed to explain the circumstances of the foreign fishing firms to Papua New Guinea's National Investment and Development Agency and other agencies concerned. Reportedly, the tax assessments against the Japanese firms will total about 300 million yen (approximately US\$1 million).

Sources: *Suisan Keizai Shimbun* and *Katsuo-maguro Tsushin*.

FISHERY ASSISTANCE EXTENDED IN CANADA

Canada's Federal Fisheries Minister Roméo LeBlanc announced a \$4 million extension to the Cold Storage and Inventory Financing Costs Assistance Program administered by the Fisheries Prices Support Board late last year. Initially approved for the period 1 July 1974 to 31 October 1974, the program was designed to assure fishermen a market for their 1974 catches at current prices and to assist the secondary industry in the orderly marketing of fishery products.

LeBlanc said this assistance will continue in the then-current form and level until 31 December 1974, and from 1 January 1975 to 31 March 1975 at a sliding rate. The program terminated on 31 March 1975. This extension provided for an orderly disposal of current inventories and prevented competition with the 1975 production. The program of credit extensions for additional inventory terminated on October 31 and was not extended.

Publications

Closed System Salmon Culture Data Issued

A report on a unique aquaculture system, developed at the University of Rhode Island, is available through the University's Sea Grant program. Entitled, **The Technology of Closed System Culture of Salmonids**, the report de-

RUSSIA AND NORWAY INITIAL FISH PACT

An agreement on bilateral cooperation between Norway and the Soviet Union in the fisheries sector was initialled in Oslo on 13 December 1974, the Norwegian Information Service reports. This was one outcome of a week of talks between the Soviet Minister of Fisheries, the Norwegian Minister of Fisheries, and Norway's Minister responsible for law of the sea and fisheries limits questions, Jens Evensen. The agreement, which is intended to further cooperation between the two countries on practical questions connected with the fishing industry, is still to be ratified. The agreement also provides for consultation on these questions with special emphasis on conservation measures and the coordination of fisheries research.

Other results of the talks were a Soviet-Norwegian agreement to propose a total 1975 quota of 800,000 tons for the Northeast Arctic cod fishery at the special meeting of the Northeast Atlantic Fisheries Commission in Bergen next January, and a Soviet acceptance in principle of the Norwegian proposal to create no-trawling areas off the coast of northern Norway. The Soviet Union is reported to have had certain reservations on the question of Norwegian jurisdiction within the zones and on the boundaries of the easternmost of the proposed zones. Questions of detail such as these remain to be settled by later discussions.

At a press conference the Soviet Fisheries Minister stressed the relationship between these three results of the talks. They were all designed to make it possible to conserve fish stocks and conduct a sensible and rational fishery in the waters off Norway and the Soviet Union, he said.

scribes the URI aquaculture system that reuses water. Key to the compact operation is biological filters that convert toxic ammonia to nitrate, a less toxic form of nitrogen.

The study was coordinated by

Thomas L. Meade, associate professor of animal science at URI, and funded by the University's Sea Grant program, part of the Commerce Department's National Oceanic and Atmospheric Administration.

The URI aquaculture system has been tested and has raised Chinook salmon from incubation to market size. It requires a relatively small volume of

water, in comparison to other methods, and eliminates the discharge of nutrient enriched waters.

Smolt production and grow-out facilities are described in the report in addition to typical problems of controlling temperature, water flow rate, and oxygenation. Also described are typical problems related to waste removal—clarification and the control of sulfide

and nitrate toxicity. A major section outlines the URI approach to ammonia control and denitrification.

Copies of the report, number P370, are available for \$1 each from the Marine Advisory Service, University of Rhode Island, Narragansett Bay Campus, Narragansett, RI 02882. Checks should be made payable to the University of Rhode Island.

NMFS Scientific Publications

Single copies of papers from *Commercial Fisheries Review* and *Marine Fisheries Review* are available from the National Oceanic and Atmospheric Administration while the supply lasts. Titles of each paper are given below and are cross-referenced by subject. Requests should be addressed to: D83, Technical Information Division, Environmental Science Information Center, NOAA, Washington, DC 20235. Please give identification number and title of the item wanted.

Airborne Sensors

- 850. Feasibility of monitoring west African oceanic front from satellites.
- 897. Airborne low-light sensor detects luminescing fish schools at night.
- 918. Observations on remote sensing in fisheries.

Alaska

- 732. Soviet and Japanese fishing activity off Alaska in 1964.
- 738. Herring fishery in southeastern Alaska.
- 741. Bottom trawling surveys of the northeastern Gulf of Alaska.
- 760. Alaska shrimp explorations, 1962-64.
- 806. Experimental trawling and pot fishing for giant Alaskan prawn.
- 821. The Dungeness crab fishery around Kodiak, Alaska.
- 825. The role of international agreements in Alaska fisheries.
- 834. Japanese longline fishery in Gulf of Alaska.
- 841. Revisions of international agreements affecting Alaskan fisheries.
- 878. Fishery oceanography—VII. Estimation of flow in Gulf of Alaska.
- 881. Herring roe: Alaska's fast-growing specialty food industry.
- 919. The growing role of interna-

tional agreements in Alaskan fisheries.

- 930. Marine life abundant near site of proposed Alaskan mill.
- 959. Japanese fishing vessels off Alaska.
- 973. Pandallid shrimp life history research at Kachemak Bay, Alaska.
- 974. Studies of spot shrimp, *Pandalus platyceros*, at Little Port Walter, Alaska.
- 980. Preliminary biological survey of log-rafting and dumping areas in Southeastern Alaska.

Alewives

- 511. Damariscotta (Maine) alewife fishery.
- 771. An evaluation of the air bubble curtain as a barrier to alewives.

Anchovy

- 907. Seasonal and geographic characteristics of fishery resources. California Current Region—V. Northern anchovy.

Aquaculture

- 772. Willapa oyster studies—use of the pasture harrow for the cultivation of oysters.
- 798. An evaluation of sampling traps in farm ponds.
- 857. Rearing larval tunas in the laboratory.
- 859. Oyster culture in Long Island Sound 1966-69.
- 976. Shrimp culture in Japan.
- 1015. The technological basis for development of aquaculture to produce low-cost food fish.

Artificial Reefs

- 1002. Effects of an artificial habitat on the marine sport fishery and economy of Murrells Inlet, South Carolina.

Bait

- 824. Rearing lugworms for fish bait.
- 925. Baitfish scouting in the Trust Territory.

Barges

- 961. Portable barge for estuarine research.

Bathyspheres

- 873. A bathysphere for fishery re-

search.

- 888. Fish behavior studies from an undersea habitat.

Billfishes

- 837. Longlining for swordfish in the eastern Pacific.
- 950. Longlines and billfish.
- 997. Investigations of billfish biology at the Hawaiian International Billfish Tournament.

Bluefish

- 940. Predation by bluefish on flatfishes.

Breeding

- 678. Accuracy of the official method of determining breeding percentages of frozen raw breaded shrimp.

California Current

- 871. Seasonal and geographic characteristics of fishery resources. California Current Region—I. Jack mackerel.
- 876. Seasonal and geographic characteristics of fishery resources. California Current Region—II. Pacific saury.
- 880. Seasonal and geographic characteristics of fishery resources. California Current Region—III. Pacific hake.
- 891. Seasonal and geographic characteristics of fishery resources. California Current Region—IV. Pacific mackerel.
- 907. Seasonal and geographic characteristics of fishery resources. California Current Region—V. Northern anchovy.
- 915. Seasonal and geographic characteristics of fishery resources. California Current Region—VI. Rockfish.
- 922. Seasonal and geographic characteristics of fishery resources. California Current Region—VII. Pacific sardine.
- 934. Seasonal and geographic characteristics of fishery resources. California Current Region—VIII. Zooplankton.

779. Seasonal and geographic characteristics of fishery resources. California Current Region—IX. Inshore sportfishes.
- Catfish**
803. New "live car" improves catfish harvesting and handling.
916. Live cars for use in catfish industry.
937. Studies of salmonellae potential in catfish feeds.
- Clams**
756. Ocean clam survey off U.S. middle Atlantic coast—1963.
776. Hard-clam explorations off southeastern United States.
788. Distribution of southern quahogs off the middle Atlantic coast.
789. A clam measuring board.
790. Sleeve for clam jetting hose connection.
791. Clam survey Ocean City, Maryland, to Cape Charles, Virginia.
793. Development of a submersible pumping system for a hydraulic surf clam dredge.
797. The Atlantic surf clam fishery in 1966.
800. Deck equipment layout on M/V "Delaware" for surf clam survey.
804. Clam survey off Virginia (Cape Charles to False Cape).
807. Special small-clam retainer and bottom sampler designed.
829. The 1967 Atlantic coast surf clam fishery.
883. The Atlantic surf clam fishery (1968).
908. Hard clam cleansing in New York.
912. The Atlantic surf clam fishery - 1969.
939. The Atlantic coast surf clam fishery 1965-69.
947. The Atlantic surf clam fishery - 1970.
954. The Atlantic coast surf clam fishery - 1971.
- Cod**
993. Slide rule for predicting shelf life of cod.
1014. Why the cod shortage? What are the alternatives?
- Composition**
613. Composition of commercially-important fish from New England waters.
765. Species composition of the North Carolina industrial fish fishery.
1022. Chemical and nutritive values of several fresh and canned finfish, crustaceans, and mollusks. Part I. Proximate composition, calcium, and phosphorus.
1033. Chemical and nutritive values of several fresh and canned finfish, crustaceans, and mollusks. Part II. Fatty acid composition.
- Crab**
619. Red crab explorations off the northeastern coast of the United States.
637. Soft-crab industry.
655. The blue crab and its fishery in Chesapeake Bay. Part 2 - Types of gear for hard crab fishery.
665. Modifications of Chesapeake Bay commercial crab pot.
680. Mechanizing the blue crab industry. Part I - Survey of processing plants.
698. Mechanizing the blue crab industry. Part III - Strengthening the industry's economic position.
718. Crab industry of Chesapeake Bay and the South—An industry in transition.
821. The Dungeness crab fishery around Kodiak, Alaska.
839. Shipping live Dungeness crabs by air to retail market.
892. Movements of tagged blue crabs in North Carolina waters.
910. The separation of crab meat from shell & tendon by a centrifugal process.
990. Sonic tags attached to Alaska king crab.
1017. The overland shipment of live Dungeness crabs by self-contained van.
1031. Observations on distribution and abundance of red crabs in Norfolk Canyon and adjacent Continental Slope.
- Dams**
840. Research on a system for bypassing juvenile salmon & trout around low-head dams.
999. Collection and transportation system of juvenile salmonids evaluated at Little Goose Dam.
- Economics**
938. U.S. fisheries: A view of their status and potential.
942. Farm Credit Act of 1971, how it affects fishing industry.
943. New England trawlermen struggle to survive.
953. Status of fish stocks off northeastern United States.
964. European demand helps spur New England shrimp catches.
977. The skipjack tuna resource (*Katsuo no shigen ni tsuite*).
981. The U.S. shrimp industry: Past trends and prospects for the 1970's.
987. Price spreads of fish products among producers and distributors.
989. Procedure for product approval and purchase: Army and Air Force Exchange Service.
991. Export opportunities for U.S. fishery products.
994. The American lobster fishery: Economic analysis of alternative management strategies.
1001. The future of the fisheries. I. The Seattle conference. II. The oceans and industry. III. Sounding our ocean future. IV. National fisheries policies and programs for our national needs.
1002. Effects of an artificial habitat on the marine sport fishery and economy of Murrells Inlet, South Carolina.
- Eels**
984. Japan's eel fishery.
985. Elver investigations in the Southeast.
- Estuaries**
827. Are estuaries necessary?
957. Effect of predators on juvenile menhaden in clear and turbid estuaries.
961. Portable barge for estuarine research.
1013. Alterations of estuaries of South Florida: A threat to its fish resources.
- Exploratory Fishing**
659. Progress report on midwater trawling studies carried out off the New England coast in 1961 by M/V *Delaware*.
764. Experimental fish trawling survey along the Florida west coast.
806. Experimental trawling and pot fishing for giant Alaskan prawn.
844. Searching for tuna.
864. Exploring for schooling pelagic fishes in middle Atlantic bight.
897. Airborne low-light sensor detects luminescing fish schools at night.
921. Underwater fishery studies are valuable.
990. Sonic tags attached to Alaska king crab.
1011. A self-contained subsurface light source system for fish attraction.
1016. Fisheries research steamer *Fish Hawk*.
- Farm Credit Act**
942. Farm Credit Act of 1971, how it affects fishing industry.
- Finfish**
795. Incidental catches of finfish in sea scallop dredges on Georges Bank.
- Fish Behavior**
888. Fish behavior studies from an undersea habitat.
- Fish Meal**
462. Pilot-plant fish-meal dryer.
705. Improved rapid method for determining total lipids in fish meal.
- Fish Migrations**
999. Collection and transportation system of juvenile salmonids evaluated at Little Goose Dam.
1000. Aircraft-refueling trailer modified to haul salmon and trout.
- Fish Oil**
676. Present and future market for fish oil.
- Fish Protein Concentrate**
591. Fish flour is primarily a protein

- concentrate—not a substitute for grain flour.
 690. MIT-UNICEF studies on the production of fish protein concentrate for human consumption.
 832. The U.S. fish protein concentrate program.
 851. Experimental production of fish protein concentrate (FPC) from Mediterranean sardines.
 895. FPC's quality virtually the same as its raw material's quality.
 901. Evidence indicates that—a premix of FPC & wheat flour can be made & transported.
 902. FPC: The NMFS experiment & demonstration plant process.
 917. Fish protein concentrates.
 1034. Using enzymes to make fish protein concentrates.

Fish Tagging

884. BCF scientists tag and recover menhaden.
 982. Menhaden tagging and recovery: Part I—Field methods for tagging menhaden, genus *Brevoortia*.
 983. Menhaden tagging and recovery: Part II—Recovery of internal ferromagnetic tags used to mark menhaden, genus *Brevoortia*.
 990. Sonic tags attached to Alaska king crab.
 1007. Sonic tags in sockeye salmon, *Oncorhynchus nerka*, give travel time through metropolitan waters.

Fishery Products

742. Pasteurization of fishery products with gamma rays from a cobalt-60 source.
 747. Reduction process to convert raw fish into thiaminase-free press cake.
 757. Identification of species in raw processed fishery products by means of cellulose polyacetate strip electrophoresis.
 879. Hurricane Camille: A new experience in reclaiming canned seafood.
 905. Fish proteins as binders in processed fishery products.
 992. Beefish patties.
 998. Improving the supply of minced blocks for the fish stick trade: A progress report.
 1019. "Kamaboko"—The giant among Japanese processed fishery products.
 1020. Surimi—A semi-processed wet fish protein.
 1029. Solubilized fish muscle as a food binding material.
 1037. Mushroom culture: A new potential for fishery products.

Fishing Equipment and Methods

724. Equipment Note No. 15—Airlift for harvesting oysters.
 735. Equipment Note No. 16—An exploratory fishing and gear research buoy.
 740. Equipment Note No. 17—

- Long-line gear improvement—Aluminum crimping sleeve prevents hook damage by electrolysis.
 743. Construction and operation of the "Cobb" pelagic trawl (1964).
 750. Wade seine construction and method of use.
 752. Trawl cod-end mesh size selectivity toward yellow perch in Lake Erie.
 754. Equipment Note No. 18—A nekton ring net sampler for use aboard oceanographic research vessels.
 759. Equipment Note No. 19—Trawl cod-end closing device.
 790. Sleeve for clam jetting hose connection.
 793. Development of a submersible pumping system for a hydraulic surf clam dredge.
 796. Development of the electro-shrimp trawl system.
 800. Deck equipment layout of M/V "Delaware" for surf clam survey.
 802. A method for tapering purse seines.
 812. How Lake Superior gill net vessel was converted to trawler.
 815. Parachute-type sea anchor.
 817. Recent innovations for trawl net reels.
 828. The fish-finding sonar of "Oregon II."
 831. A floating trap net for use in reservoirs.
 833. A machine for winding trawl cable.
 862. Otter trawling introduced to Columbia River smelt fishery.
 869. Night lighting for herring—An old technique may have new possibilities.
 874. Experimental sablefish fishing off San Diego, California.
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964. European demand helps spur New England shrimp catches.
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753. Skipjack tuna (*Katsuwonus pelamis*) resources of the Trust Territory of the Pacific Islands.
766. The South Pacific long-line fishery for albacore tuna, 1954-64.
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783. An aircraft and vessel survey of surface tuna schools in the Lesser Antilles.
813. South Pacific landings of skipjack and yellowfin tuna at Papeete Market (Tahiti).
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853. Tuna purse seine fishery in eastern tropical Atlantic.
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857. Rearing larval tunas in the laboratory.
977. The skipjack tuna resource (*Katsuo no shigen ni tsuite*).

Shellfish, Shad, and Tuna Travel

... **New York State's shellfish industry could benefit** from a 3-year study of alternative management strategies for the Atlantic coast clam industries, reports *Coastlines*. The project, undertaken by several state universities in the Northeast, hopes to identify feasible alternative management plans and consider their impact on the resource, harvesters, recreational clam diggers and consumers. The industry's present structure will be studied, looking at the harvesting, handling and processing sectors. An attempt will be made to assess present and future supply and demand in the shellfish industry. . . .

... **Lake Michigan's alewife catch appeared well on its way** to a near-record total by late summer according to the *The Great Lakes News Letter*. Some 33.2 million pounds of alewives had been landed to the end of August last year, an amount surpassed only in 1967 when the catch for that period was about 36.9 million pounds and hit 41.2 million pounds for the full year. The year 1973 had been second highest with landings of 30.3 million pounds through August and a total of some 36.5 million pounds. Alewives are mainly used for fish meal, oil, and in pet foods. Their value through last August was about \$458,000—or 1-2 cents per pound. . . .

... Preliminary results of a study aimed at mapping migrational patterns of marketable-sized blue crabs in Florida's coastal waters indicate that the species may range over a wide territory. Early tag-recapture program findings indicate that the **source of blue crab fisheries may be many miles** from the actual harvest areas. The crabs appear to be on the move primarily during the fall and winter months and to move in a northerly direction along the Gulf coast, according to researchers in the *Florida Conservation News*. No significant movement pattern has been noted during the spring and summer months. . . .

... The Fish Commission of Oregon has announced a December 15 commercial Dungeness crab season opening

instead of the usual December 1 date, a move described as a **first step in establishing a uniform opening date for commercial Dungeness crabbing**. Should Washington and California fail to set the same opening date, Oregon is expected to revert to its customary December 1 opening for the 1975-76 season. The Oregon Fish Commission also required installation of 4 $\frac{3}{8}$ -inch (inside diameter) escape ports in new crab pots used there in 1975 to prevent capture of undersize crabs. The Commission is allowing a 5-year phase out of existing pots. . . .

... **Alaska has won the largest water pollution case penalty** ever assessed, \$429,000, reports the U.S. Environmental Protection Agency. Charged with violating a state permit to discharge waste water into Cook Inlet from its Kenai fertilizer plant, the Collier Carbon and Chemical Corp. pleaded no contest and agreed to civil damages. Criminal fines of \$129,000 and a \$300,000 civil penalty were levied against the firm, a subsidiary of the Union Oil Company of California, after a trial in a Kenai, Alaska Superior Court. . . .

... To protect striped bass for sport fishermen while continuing an optimum commercial shad harvest, the Fish Commission of **Oregon has announced a 30-pound maximum mesh breaking strength limitation on shad net** for 1975. In 1976 all coastal shad nets will be limited to a 24-pound maximum breaking strength. The requirements will make it illegal to fish with heavy nets which could be used for catching large bass, says the Commission. The incidental catch of striped bass in coastal shad fisheries is thereby expected to drop. . . .

... **Australia recorded its worst rock lobster season in five years** as the 1973-74 catch totalled slightly more than 13,000 metric tons according to a report in *Australian Fisheries*. Production for all States was 15 percent below that of 1971-72 and 72-73 when it was slightly more than 13,000 metric tons. The high-

est recorded catch of rock lobsters there was 15,096 mt in 1967-68 and the lowest in the last decade was 11,450 mt in 1969-70. . . .

... The landed value of **New Zealand's fisheries catch in 1973 hit a record \$NZ21,544,124**, according to reports in *Catch '74* and *Australian Fisheries*, exceeding the 1971 record by about \$NZ2 million and the 1972 figure by about \$NZ4 million. Snapper (*Chrysophry auratus*), comprising about one-third of the wetfish landings, was the principal fish caught; landings of gurnard, barracouta, and albacore were up while eel and trevally landings fell. Rock lobsters led the fisheries in value at nearly \$NZ9.5 million with wetfish next at slightly more than \$NZ8.5 million. . . .

... Tagged in June 1974 off Japan by scientists with the Far Seas Fisheries Research Laboratory, Shimizu, Japan, **two albacore tuna were recaptured 3 $\frac{1}{2}$ months later off the northern Oregon coast** by U.S. fishermen during the 1974 Pacific West Coast albacore fishing season, according to the *Tuna Newsletter*. These are the first such tagged tuna recovered off North America. . . .

... A record return of **6,260 pink salmon marked the fourth year of a gravel incubation system** test in Auke Creek near Juneau, Alaska. The average pink salmon run here in recent years has been about 2,500 pinks and the previous known high before installing the gravel incubator was 3,800. The 1974 return included 644 marked hatchery fish from 553,000 fry, and 71 marked wild fish from 74,000 fry from natural spawning in the creek. Average survival for all fry released in 1973 was one percent, the Alaska Department of Fish and Game reports. . . .

... Australian rock lobster **"catchability" is affected by molting, water temperature, and "the well-known influence of the moon,"** according to a Western Australia research project report in *Australian Fisheries*. Rock lobster flesh in the pots strongly deters others of the species from entering, it was noted. Trapping success has been achieved using large pots with multiple eyes, and with a South African-designed catch sorter to eliminate undersized rock lobster. . . .

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